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CHEMICAL SECTION.

(*Concluded from vol clxi, page 58*).

*Mica and the Mica Industry.

BY GEORGE WETMORE COLLES.†

Average Prices.

An important element in statistical values is the average *prices* of the product, more especially when taken in connection with charts for total values and quantities. *Average* prices of miscellaneous products of assorted sizes, can of course be of no service to those requiring to purchase or needing for service a particular size or sizes, but they are of real importance to the mining industry, because they designate the real value which may be counted for the run-of-mine product. We will next consider, therefore, two charts, Figs. 31 and 32, showing the

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average prices of the sheet in the respective countries of production, and also the prices received for the different varieties of our native product. In Figure 31 the first thing that strikes the eye is the character of the United States price-curve,

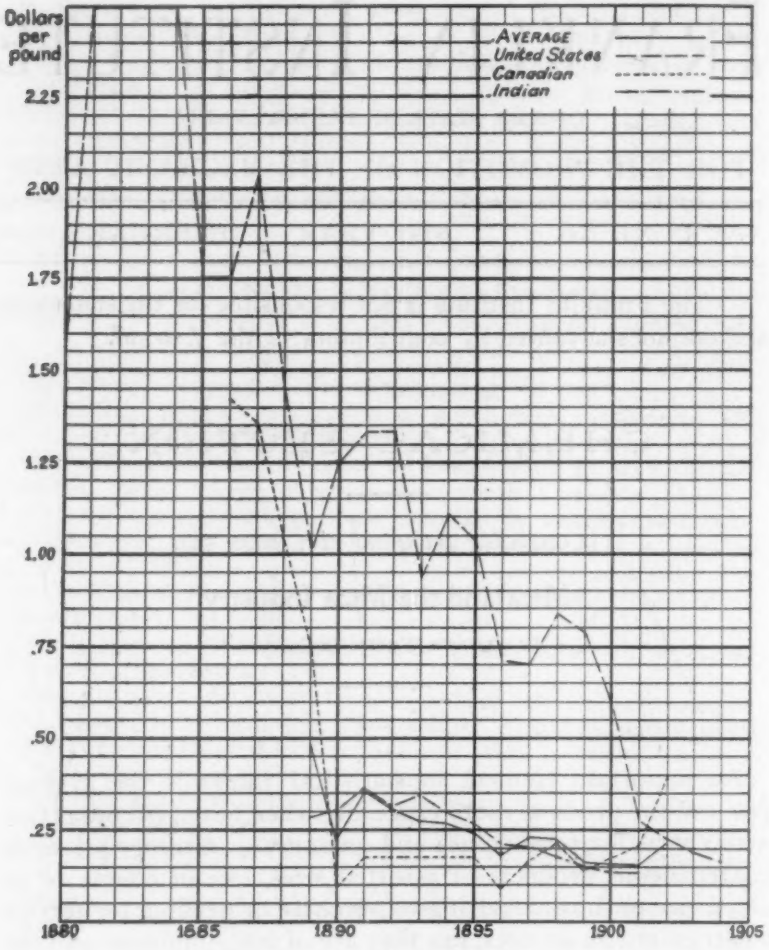

Fig. 31. Average Prices of Sheet Mica.

which slants steeply downward from a generous $2.50 a pound in the early eighties to a beggarly 16.4 cents in 1903,—not to mention the $8.00 a pound which was received in the sixties.

Oh, what a fall is this, my countrymen! Can there be any wonder if mica-mining has ceased to be profitable?

True, not alone United States mica has suffered this fall. So has Canadian mica; but it is clear that the $1.42 rate for the latter was very far above its proper level. This rate was merely assumed when Canadian mica began production in 1886, because of the prevailing high price in this country; but as soon as production seriously began, the price rapidly fell to nine cents per pound, and pulled our domestic product down with it to half-price.

While United States mica has fallen off continuously in value, Canadian mica has been, since 1896, in the course of recovery, and in 1902 ran higher than United States mica. And there is reason that it should do so; its superior merits for electrical purposes have been slow of appreciation by users, and it has only begun to take the position in this respect that it has a right to claim. During the same period, the average price of Indian mica has fallen steadily from 30 to 35 cents in 1891 to about 14 cents in 1901, and is now reckoned at a lower value than either of the others.

The general price of mica has likewise fallen during the entire period under consideration, keeping pretty close to the India line, and is now reduced to less than half its former value. This is undoubtedly to be explained by the increased competition, and that more particularly in India. The increase of competition has been doubtless called forth by the increasing demand for mica for electrical purposes. The opening of the new Madras mica district of India in 1897 has undoubtedly also had a strong effect on the reduction of the price, adding an annual output of some 300 tons to the supply. The great increase in the supply can in fact readily be seen by referring to Figures 26 and 27.

A most interesting point in connection with this chart is the question of the effect the increase of the tariff on mica has had on the price in this country. Prior to 1892 mica came in free. From that time until July 24, 1897, the tariff was 35 per cent., and subsequent to that date the combined specific and ad valorem duty has averaged 45 to 60 per cent. We cannot, however, observe any permanent effect on the price from these

tariff duties, although perhaps a temporary effect may be discerned in the high levels of 1892 and 1898. The tariff, if it was its object (as it really was) to exclude the foreign product, has

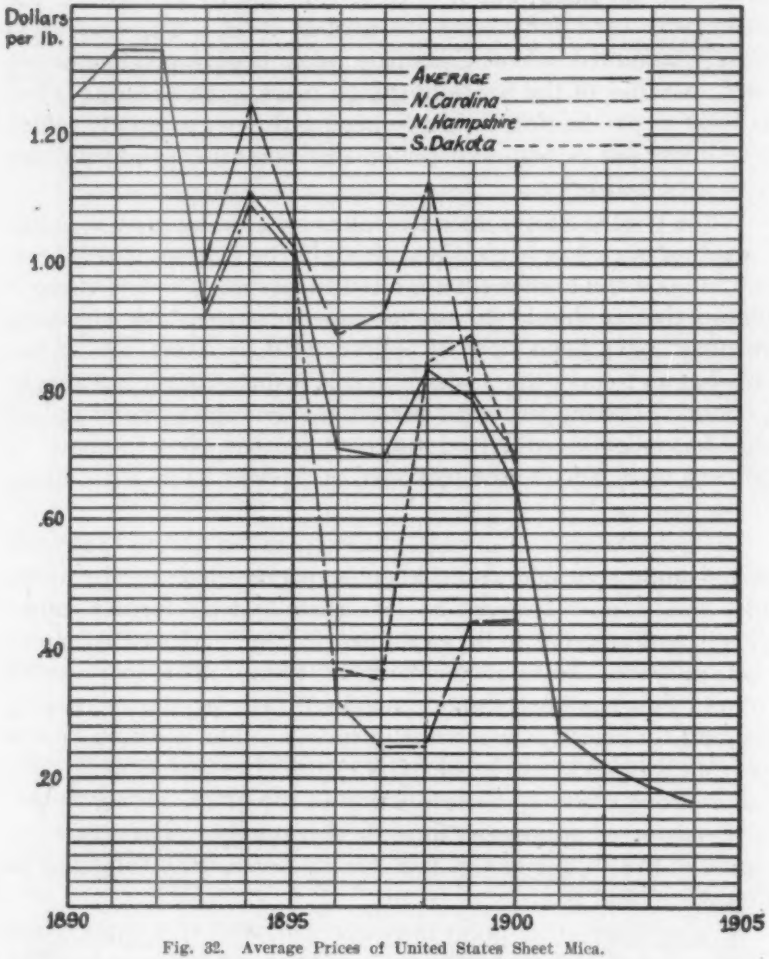

Fig. 32. Average Prices of United States Sheet Mica.

totally failed of effect, and this we shall see even more clearly in considering one of the following charts.

In Figure 32 we can compare the average market prices of North Carolina and New Hampshire and South Dakota mica, as deduced from the reports collected by the "Mineral In-

dustry." North Carolina is, and always has been, rated at a higher value than New Hampshire mica, and probably always will be, for it is of undoubtedly superior quality for the purposes for which it is used, namely, glazing, to any elsewhere produced. Both New Hampshire and North Carolina mica have necessarily fallen in value with the course of the average curve; but New Hampshire has fallen the most, and although values are only given to 1900, they are believed to have sunk still lower since that date, and have practically put an end to the New Hampshire industry. It is surprising that South Dakota mica should show such a great increase in average price from 1897 to 1898, and it is thought that these figures are not to be relied on.

There is a very important point to be noted in connection with these price diagrams, however, and which renders the wide differences observed more apparent than real. It is this: That the value of the mica will naturally depend on the condition of manufacture, and this is different in different localities. Practically all the North Carolina mica is shipped, as it always has been, cleaned and cut into rectangular panels, ready for use by the stove manufacturers; whereas a large proportion of that from New Hampshire is sent to market as trimmed mica, whose value *per pound* is not more than 40 per cent. of the value of what is left after cutting, on account of the waste. But aside from this, the average value is largely influenced by the sizes obtained. It is less because of its inferior quality than because of its small sizes that the *average* price of New Hampshire mica is lower. Indeed, much of what is sent to market as sheet in New Hampshire to be cut into small electrical forms, is termed scrap in North Carolina, and, if not suitable for grinding there, never leaves the dumps.

These points are also to be considered in connection with the foreign products. At the present time and for some years past none of the product of Canada, and only a small proportion of that of India, is cut into panels or other shapes in the mines; so that the quantities shipped are really much larger than the quantities of corresponding value in cut mica shipped in the United States, and show correspondingly in the price charts, and on the quantity lines of the production charts.

Valuation of United States Imports. Fig. 33.

This chart is of great interest and importance as indicating the actual valuations at which the foreign product comes into competition with that of the United States, and the effect, or rather the lack of effect, of the imposed duty. Two sets of lines are shown, one indicating the invoice-price of imports in dollars per pound, the other the invoice-price with the addition of the duty; and independently of these is shown a duty line

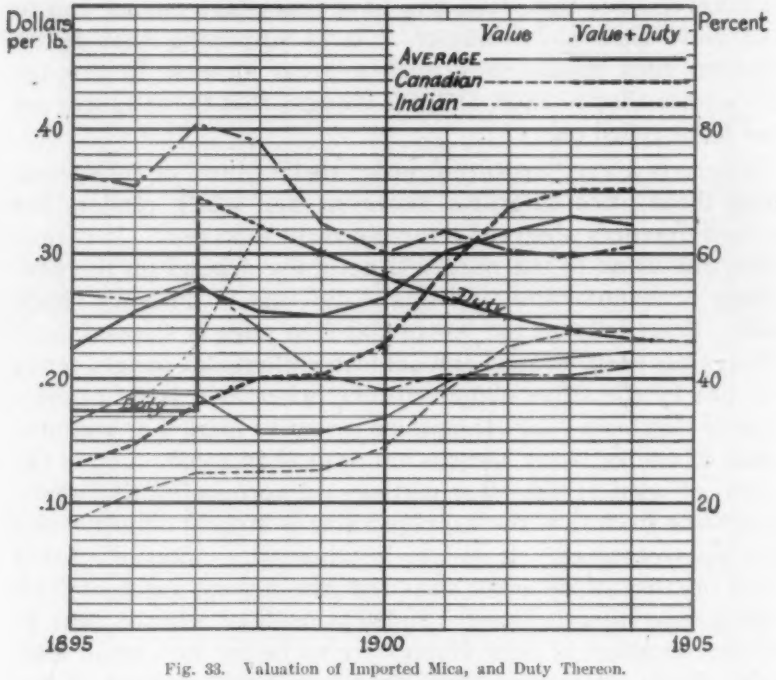

Fig. 33. Valuation of Imported Mica, and Duty Thereon.

indicating the *equivalent* ad valorem rate. This latter shows that from a fixed rate of 35 per cent. previous to 1897 the duty rose in that year to 46 per cent. and in the following year to about 64 per cent., since which time it has been regularly declining. The reason for the decline is to be found in the increased average price per pound on the invoices, the specific proportion of the duty being of course equivalent to a lower ad valorem rate as the price increases. It is not explained by any change in the proportion of manufactured to unmanufac-

tured* mica, the former kind having remained fairly steady since 1899† at 3 to 5 per cent. of the total quantity , and 9 to 12 per cent. of the total value.

Practically all the imported mica, therefore, comes to us in a merely trimmed condition, in which condition it is more suitable of electrical purposes, owing partly to the irregularity of the shapes in which it is used in the simple form, and partly because a large if not the greater proportion is used in the manufacture of mica board or compound forms, such as rings, sleeves, tubes, etc., in which the individual laminæ of mica are irregularly cemented together.

The increasing appreciation of Canadian mica is readily seen from this chart. It has been increasing steadily in value from 1895 to the present time, and that of India has been almost as steadily decreasing in value; so that, where in 1895 the imported value of Indian mica was 36.3 cents, or nearly three times that of Canadian mica, in 1904 Canadian mica stood at 35.1 cents and Indian at 30.7 cents. Even more significant, perhaps, is the fact of the well-defined and fairly steady increase in the average value of imported mica from 22 to 32 cents per pound, while during the same period United States mica was falling from $1.00 to 16 cents.

It is clear that the change in the rate of duty has had no perceptible effect either in keeping up the price of the United States production, or in keeping out imports, the former having decreased, and the latter increased quite without regard to such changes. The conclusion to be drawn from this state of affairs will be set forth in the following section.

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*The specific rate on unmanufactured mica is six cents, and on "cut or trimmed" mica twelve cents per pound. The actual line of division between the two seems to be uncertain in the Treasury itself, for I am informed that both knife-trimmed and thumb-trimmed mica, even when the product is split into thin sheets and cleaned, is rated as "unmanufactured." It is certainly true that thumb-rimmed mica is and always has been so classed. It fact, it would be difficult to draw any line between raw mica and thumb-trimmed, which would permit any mica to be imported at the lower rate.

†In 1899 it was 6 per cent. of the total quantity and 18.1 per cent. of the total value.

Proportions of Sizes in the Total Production. Fig. 34.

The only complete statistics on this subject are those furnished for Canadian mica, and these illustrate very well the proportion of the output of the Canadian mines, though of course those of the Indian, North Carolina and New Hampshire mines and other mines would be quite different in each case. The output of Canadian mica classified in sizes for the three years, 1899, 1900 and 1902, are as follows:

From the percentage-figures for total quantities and values the chart shown in Figure 34 has been prepared.

Prices of Different Sizes.

From the preceding table price-curves have been also charted in Figure 35, for the three years above given, which will indicate pretty clearly the wholesale rates for Canadian mica. In the United States a price-schedule is determined on by the mica-dealers and published annually. This schedule for the years 1897, 1898 and 1902 is given below. There are discounts of 50, 10 and 5 per cent. from the schedule, and the prices with all of these discounts deducted, are also shown in the table.

LIST PRICES OF CUT INDIA AND NORTH CAROLINA MICA.

Size	List Price			Net, with Discount		
	1897	1898	1902	1897	1898	1902
1 x 4	.90	1.15		.384	.492	
2 x 2	.60	.85		.256	.363	
2 x 4	1.20	1.45	.30	.513	.620	.128
2 x 6	3.00	3.25		1.28	1.39	
3 x 3	2.50	2.75	.80	1.07	1.18	.342
3 x 4	5.00	5.00	1.50	2.14	2.14	.641
3 x 6	8.00	8.00		3.42	3 42	
4 x 4	7.00	7.00	2.00	2.99	2.99	.855
4 x 8	9.75	9.75		4.16	4.16	
6 x 6	10.00	10.00	3.00	4.27	4.27	1.28
6 x 8	10.75	10.75		4.60	4.60	
8 x 8	12.00	12.00		5.73	5.73	
8 x10	13.00	13.00		5.56	5.56	

It will be understood that the "nominal size" of a piece of trimmed mica is the size of the largest rectangular sheet without flaws which can be cut from it. Indian mica is not classified in this way, but according to numbers and grades. The numbers are specified in available square inches as follows:

PROPORTIONS OF SIZES OF CANADIAN MICA, 1899-1902.

Nominal Size	Equivalent Sq. Inches	1899					1900					1902 (Quebec only.)				
		Quantity		Value		Avge Price per lb.	Quantity		Value		Avge Price per lb.	Quantity		Value		Avge Price per lb.
		Pounds	% of Total	Dollars	% of Total		Pounds	% of Total	Dollars	% of Total		Pounds	% of Total	Dollars	% of Total	
1x3	3	284,036	42.9	$18,926	17.5	$ .067	338,200	62.5	$31,860	30.3	$ .094	64,463	48.5	$ 7,364	20.5	$ .114
2x3	6	136,054	20.5	19,146	17.7	.141	92,359	17.1	18,534	17.6	.201	27,861	21.0	7,201	21.0	.258
2x4	8	179,113	27.0	32,721	30.3	.183	71,332	13.2	24 953	23.7	.350	27,296	20.6	10,756	31.4	.394
3x5	15	37,284	5.6	16,720	15.5	.449	25,637	4.7	15,706	14.9	.611	11,772	8.9	7,578	22.1	.646
4x6	24	17,937	2.7	10,908	10.1	.608	11,762	2.2	11,451	10.9	.974	890	0.7	820	2.4	.921
5x7	35											540	0.4	585	1.7	1.183
5x8 & over	40	7,767	1.2	9,642	8.9	1.240	1,995	0.4	2,696	2.6	1.351					
		662,191		108,063		.163	541,285		105,200		.194	132,822		34,304		.258

1. 36 to 50 sq. in.
2. 24 to 36 " "
3. 16 to 24 " "
4. 10 to 16 sq. in.
5. 6 to 10 " "
6. 4 to 6 " "

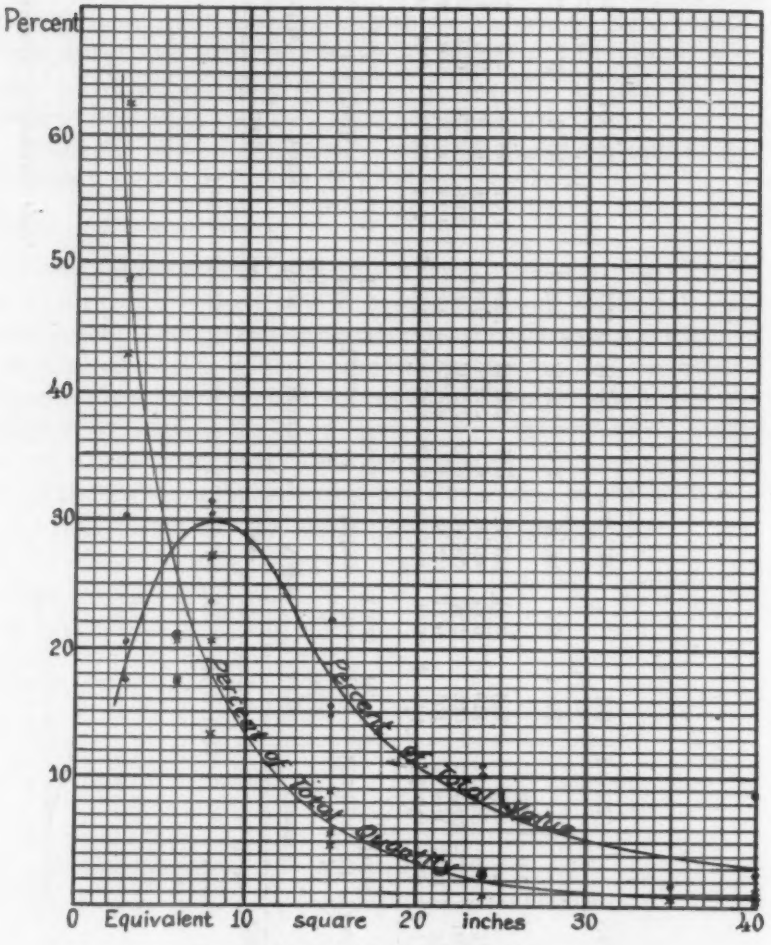

Fig. 34. Proportions of Sizes of Canadian Mica.

Sheets over fifty square inches in available area are termed "specials."

The grades are as follows: (1) Ruby mica, hard and tough; (2) white, transparent; (3) discolored and smoked; (4) black

and flawed. Each of these grades represents about double the value of a sheet of the same size in the next lower grade.

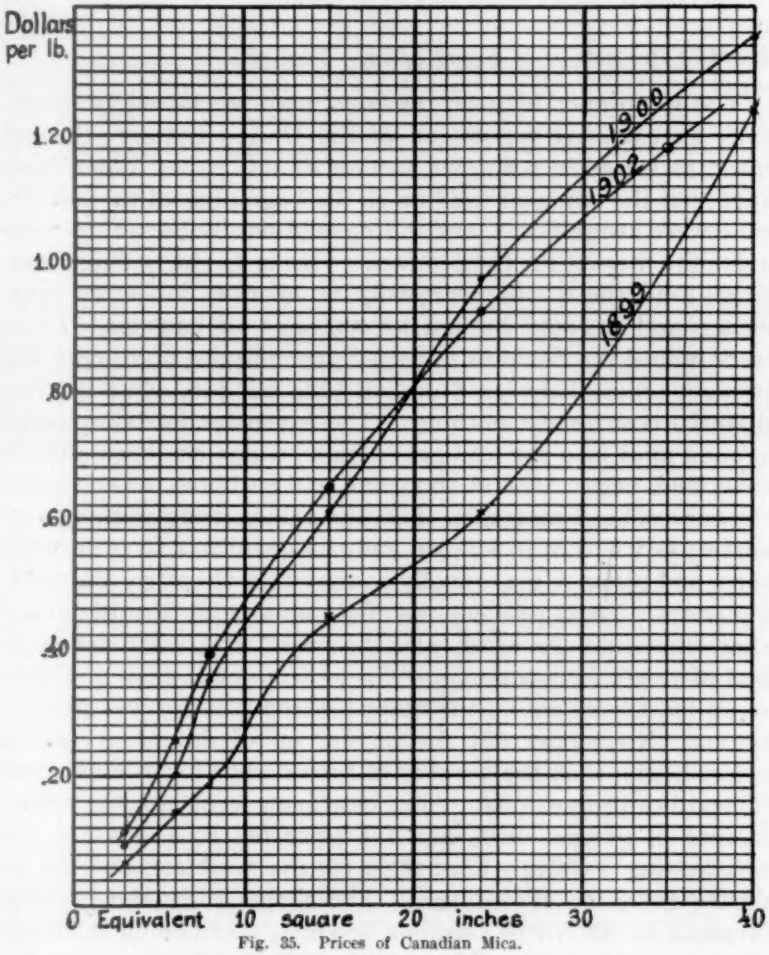

Fig. 35. Prices of Canadian Mica.

The following quotations on best ruby, No. 1 grade, were made by auction in London, according to A. Mervyn Smith:*

*Proceedings Institution of Mining and Metallurgy, Volume VII, page 171.

No. 1.	6s 8d.	= $1.62		No. 4.	1s	= $ .24
" 2.	4s	= .97		" 5.	4d	= .08
" 3.	2s	= .49		" 6.	2d	= .04

Specials bring as much as £1 per pound.

World's Production of Scrap Mica. Fig. 36.

The scrap mica industry, at least, may be classed as practically an exclusive possession of the United States. Ground mica, as stated in a former section of this paper, dates from 1870, but the amounts used up to the beginning of the last decade were insignificant, and there could hardly be said to exist a definite market for the product. Owing to the trifling quantities used there was practically no market for scrap-mica, either, and it could be had for the cost of haulage. These were indeed the bonanza times for ground-mica producers, the product selling between $100 and $200 per ton, while the raw material cost almost nothing. The extensive introduction of ground mica into the wall-paper trade, which has been already described, began around 1890, and had its boom, as shown by the curves, beginning with 1896, the values rising in three successive years to over $50,000 and the quantities to over 7,000 tons, and collapsing as rapidly as they rose to nearly the starting point. These peaked, one might almost say absurd curves, show the ordinary result of a "corner" in a small industry, and of a very foolish one, too, for to attempt control of all the scrap mica lying on all the dumps of the country was preposterous. No sooner did the buying up of dumps at famine prices begin, than the number of such dumps for sale assumed unheard-of proportions. Also, new firms went into the manufacture of ground mica, and the price fell to about $40 per ton, leaving positively no margin for the producer, and the industry collapsed accordingly. The curves show the greatest increase in the North Carolina product, there being but little scrap available in New Hampshire, as it had been used up before. The increase, however, was not really due to actual production, but merely to the throwing on the market of the aforesaid dumps, which were the product of the previous years' work and had suddenly become valuable. The writer has made a vain effort to secure statistics of prices of scrap and

ground mica, which would enable charts of prices to be drawn. The industry being a small one, the "friction of trade," as it is called, is very great, and the prices slide from one level to another by big jumps from time to time, keeping constant,

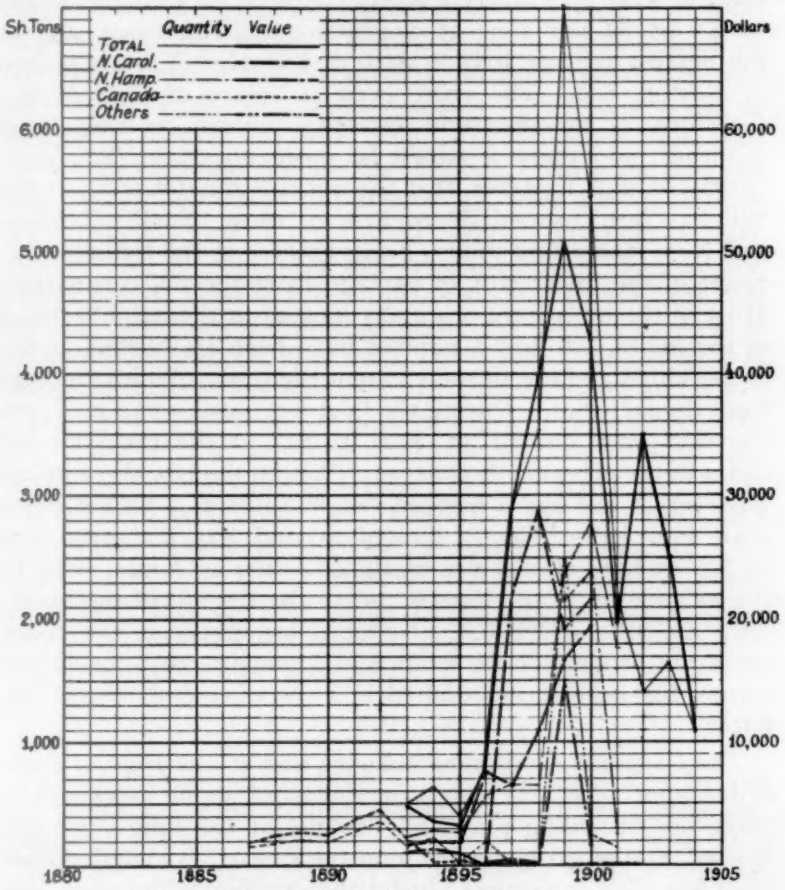

Fig. 36. World's Production of Scrap Mica.

nominally at least,, in the intervals. Actually the prices are more or less subject to secret discounts, which renders any quotation chart which might be formed practically valueless. The value of scrap, moreover, varies widely with the place of production, not only because of the difference in proportion of

scrap mined in the different districts, and the different proportionate values of the sheet product, but also, and more especially, because of the great differences in the cost of hauling to market, which may equal or exceed the value of the scrap. The value of scrap on a dump in North Carolina, for example, might be $1 or $2 per ton; at a near-by mill, or town, $5; at the nearest railway station, $10; and at New York, Chicago or Boston, $20. The value even at "place of production," therefore, is an uncertain quantity, unless on the dump is meant, and there it would be more uncertain than ever. It may be said, however, that the normal value of scrap at the mill has been around $7 to $10 at most North Carolina and New Hampshire mines, being greater at the latter on account of the lower cost of haulage from the mill to market. Most of the mills were originally located in the neighborhood of the mines, but now a number have been established at the larger cities, and use to some extent the waste of mica cuttings from the factories. During the "corner," mica-scrap in North Carolina was quoted at $12 to $15 at the mill, but fell again in the subsequent collapse. Within the last three years, however, it has had a marked rise in value at a higher point than ever before, being quoted around $25 and even $28 to $50 in New Hampshire in 1902,*—due, no doubt, both to the exhaustion of old dumps and to the decline of the sheet-mica industry, which has, of course, brought a severe check upon the production of scrap, and lowering the price of the former has necessarily resulted in a corresponding rise of the latter.

The Canadian scrap-mica industry was at one time of some little importance, reaching a maximum of about 3500 tons in 1892, but becoming practically extinct at the time when the United States ground-mica industry began. Ground amber mica has a lower degree of luster than ground white mica, and the product is consequently inferior for decorative purposes, which, added to the duty of 20 per cent., has practically excluded it from the United States, its only market. It has had some use in lubricants, paints, and the like, but the amount

*Albert F. Hoskins, in "Mineral Industry," 1903.

used of these materials in Canada is insufficient to support a ground-mica industry.

Of course it is to be anticipated that, should the United States mica industry decline again as in the early nineties, the price of domestic scrap will rise to such an extent as to render the importation of Canadian ground mica necessary. Under the present tariff, however, it would be impossible commercially to import Canadian scrap on account of the six cents per pound specific duty, equivalent to $120 per ton. The importations of the ground product are taxed at 20 per cent. ad valorem, thus rendering its importation less difficult. However, it can hardly be supposed that this product can ever wholly, or even largely, replace that of the United States. No other country produces any ground mica, and consequently, aside from the United States, Canada is our only outlook for either the raw material or the finished product under the present tariff, as it can hardly be supposed that there would ever be an industry in Europe exclusively for supplying the United States, and it is a strange and interesting fact that Europeans apparently make no use of this material except for the small quantities that are exported from the United States.

It has been assumed in this discussion of the scrap mica production that all of it was used for the purpose of grinding. Of course there are certain amounts of mica classed as scrap which are actually used for such things as small electrical insulating plates and washers, but most of the material used for such purposes is classed as sheet mica.

VIII. CONCLUSIONS.

From a consideration of the facts hereinbefore cited we are in a position to draw certain conclusions of more or less importance.

We have seen that there is an important natural division line between the micas, dividing them into two classes, having not only different physical and chemical characters, but with most important commercial differences in respect to hardness, flexibility and coloration. The harder and more brittle—igneous—micas are the only ones suited for glazing; the softer and more elastic best suited for most electrical purposes.

This line, commercially speaking, is not absolute, however, for much of the former class, especially that containing lithia, has a softness and flexibility nearly if not quite equal to the latter.

Moreover, the line of division is not drawn through the center, so to speak, but on one side. Only one locality furnishes mica of the second class;* but mica of the first class is found in commercial deposits in most countries of the world.

The two classes also differ very much in their respective facilities of mining, that of the first class being found in hard, flinty and feldspathic rocks, or their derivatives, and then in isolated bodies which must be recovered individually; while mica of the second class occurs not only in softer rocks—calcite, apatite and pyroxene— but also in dense masses, rendering the mining cost but a fraction of that for the first class of mica.

In neither class, however, is there any deficiency in the natural supply, which acts as a factor of any importance in the price. In this respect mica stands apart from the generality of minerals, the supply of which is limited to a greater or less extent through a scarcity of the deposits; it stands rather on a par with materials like building-stone, slate and cement, but differs from these latter in that the price per pound is so much higher that the cost of transportation is generally of small account. Not only are there in many countries unlimited deposits of mica which have never been seriously worked, but even in the producing localities the surface of the deposits has scarcely been scratched. In Canada, North Carolina, New Hampshire and even in India there are great numbers of deposits of good quality which are not worked, and that which is worked, as in India, is worked very wastefully and a large proportion of the total output is spoiled.

The reason for the limitation of the production to three countries is due to special conditions. India naturally takes the lead in production for three reasons: First, the excessively low cost of the unskilled labor necessary; secondly, the decomposed nature of the rock in which most of the mines are

*It is understood that amber-colored mica is mined in India; this may or may not be phlogopite, but it does not make its appearance in our markets.

located; and thirdly, of course, the great abundance and good quality of the mica itself. These conditions practically place other countries out of competition with it.

Canada, however, is an exception to the fact just noted, in that it alone possesses magnesian mica, and this mica is mined with so much greater facility than the other that even with a higher cost of labor, it can be placed on the market quite as cheaply as that of India. It has, besides, an added advantage of transportation, but the most important fact is that Canadian mica is *better* than Indian mica for certain purposes, and is therefore preferred, and will continue to be used without much reference to price differences.

The last remark is also applicable to North Carolina mica and explains, I think, sufficiently its reason for existence at a time when in the matter of price it cannot approach the other two varieties. The addition of 25 or even 50 cents a pound is a matter of small consequence in the glazing art, where it is desired to have the best, and where the total cost of the mica used is but a small element in the cost of the manufactured article, and detracts little from the profit.* For this reason it is believed that North Carolina will also continue to be a mica producer to some extent, whatever the course of future prices may be. The same, however, cannot be said in the same degree, of localities like South Dakota and New Hampshire.

There is another feature, however, to be considered in this connection as helping to enable the domestic industry to hold its own; namely, the production of scrap, which will undoubtedly continue to increase from year to year, although it can hardly rise to any very voluminous proportions. Now the scrap and sheet-mica product together form the support of the industry, and it follows that one must rise as the other falls, and conversely. If then the price of sheet mica falls from 50 to 25 cents per pound, it is natural that the price of scrap should rise from $7 to $25 or even $50, as we see that it has done. We have seen, moreover, that the United States

*An ordinary sheet of stove-paneling, 4x4 inches, weighs about $\frac{1}{160}$ to $\frac{1}{185}$ of a pound, and would cost from one to two cents or less. For such purposes as lamp-chimneys it is absolutely necessary that perfectly colorless mica be used.

ground mica industry is practically dependent on the United States for its supply of scrap, and is likely to continue to be, and this alone will form a source of support for mica mining in the United States. A price of $25 to $50 a ton for scrap looks high indeed from our former condition, but there is really no reason why it should not remain there if the industry requires it, for the grinding can be done at a profit for $40 per ton, and there is no question but that the ground mica trade can endure the price of $80 to $100 per ton.

The mica industry is influenced fundamentally by the uses to which the product is put, for as we have seen, these uses are special in their nature. In consequence the different classes of mica come only slightly into competition with each other, and the corresponding branches of the industry are semi-independent of each other. Electrical mica is not suited for glazing, nor is glazing mica best suited for electrical uses. If, indeed, either class of mica should become very scarce, we might expect a considerable influence upon the mining of another class, but so long as prices remain within reasonable limits, there is no special inducement to substitute one class for the other. This is convincingly shown by the absolutely imperceptible effect of changing tariffs upon the imports and prices. Of course, India mica to a large extent competes with both Canadian and domestic, and owing to a general ignorance of the subject, prices have doubtless been due largely to prejudice; but the enormously increased use of mica in the past ten years have served to bring each more nearly to its respective level.

During the whole of the last decade the future of our mica industry hung in the balance; but in the last few years it has assumed a new aspect, due undoubtedly to the stimulus of enterprise in the western fields, and now, even with the prevailing prices lower than ever before, it is rapidly forging ahead. It must be assumed that this new condition is due to a change in the method of mining rather than to new possibilities of exploitation or a new use for the product.

The New Hampshire industry is practically extinct, and must become absolutely so in a few years unless a growth of the ground-mica industry should take place beyond what it is reasonable to expect.

In spite of the recent great relative increase in importance of the western mica, the greater possibilities of the future undoubtedly lie in the state of North Carolina. A mica field equal in quality of its product to that furnished by this state for glazing purposes is yet to be discovered.

There seems to be no likelihood of any new districts becoming producers on an important scale. The industry is so well established in India under European control that it unquestionably has a lead which it would be difficult for a new district to overcome without some special reason; and there is no doubt that by the introducing of more system and the prevention of waste in the Indian mines, the mica could be produced at lower cost even than at present; and there is no doubt of the ability of India to supply the world with all the mica that it needs.

Large sizes, both in glazing and electrical mica, more especially the latter, have undergone a permanent decline. The increasing use of artificially-compounded board, and its manifest superiority from an electrical standpoint to the large sheets, indicate that these will never rise again to their former value. Precisely how great an effect on the price per pound has been caused by the proportionate increase of the use of small sizes and the decrease in large sizes, it is difficult to say, but it undoubtedly has had an influence in determining the average price per pound of marketed mica, by increasing the amount of utilizable material per ton of rock mined.

Finally, it may be said that the mica industry at large is certain to increase in the future as it has in the past. Its industrial position is for all practical purposes impregnable. In its two principal uses no substitute for it is known, nor is one in the least likely to be found, which can have any market effect on its production. More especially the electrical industries, it is well understood, are on the increase, and that of mica must increase concurrently. True, the percentage of installations which use direct current (for which commutators are necessary) is on the decrease, but it is hardly to be supposed that the actual number of direct-current machines in use can decrease; these machines must use commutators, and the commutators must be insulated with mica. Mica has been and can be artificially prepared; but the conditions under which

natural mica is produced seem to place its artificial manufacture on a commercial scale beyond the range of reasonable possibility; and should any new art arise requiring the use of mica on a large scale, it would of course give a large additional impetus to mica production.

[THE END.]

TITANIFEROUS IRON ORE.

The blast-furnace is not suitable for the reduction of titaniferous iron ore. But in the electric furnace it is possible to obtain a final product containing a large or small percentage of titanium as desired. The advantage of the treatment of titaniferous iron ore, vast quantities of which exist in the United States, lies in the value of the by-products, particularly the ferro-titanium and titanium carbide.—*Eng. and Min. Jour.*

PHILADELPHIA FIRE ESCAPES.

A type of fire escape has been developed under the Building Laws of Philadelphia primarily for use in factories, which is so remarkably efficient and so far ahead of safety of anything else that exists, that we may wonder why it has not been copied in other cities. It is somewhat expensive, but the safety it gives is well worth the extra cost. The fundamental idea is that the stairway tower is absolutely cut off from the various rooms and floors which it serves. One must go out from the room into the open air and then enter the stairway. Once within this, he can proceed without danger to the bottom. The same idea can be applied to the fire escapes from a theatre.

ALUMINUM-ZINC ALLOY.

An alloy of two parts of aluminum and one part of zinc is equal to good cast iron in strength, and superior to it in elastic limit. Its color is white. It takes a fine, smooth finish and does not readily oxidize. It melts at a dull red heat, or slightly below, and is very fluid, running freely to the extremities of the mold and filling perfectly small or thin parts; in that respect it is said to be superior to brass, but it is brittle, and hence unsuited to pieces which require the tougness possessed by brass. The tensile strength of the alloy was found to be approximately 22,000 pounds per square inch, and its specific gravity 3.3.—*Eng. and Min. Jour.*

Section of Physics and Chemistry.

(*Stated Meeting held Thursday, November 9th, 1905.*)

Labor-Saving Appliances in the Laboratory*

By Edward Keller, Baltimore, Md.

[The author in this paper describes and illustrates a number of improved methods and apparatus introduced in the newly equipped assay laboratory of the Anaconda Copper Mining Co., in Baltimore.—The Editor.]

Having been authorized by the Anaconda Copper Mining Company to build a new laboratory in Baltimore, Md., a works-laboratory in which the chief duty is to determine the values of copper, silver and gold in crude copper, the writer determined to make its equipment superior to any he had seen in this country and abroad. The result of this effort is given in the subjoined description:

CONVENIENCE FOR HANDLING BEAKERS AND ACIDS.

Assaying forms the bulk of the work at the Baltimore laboratory. Scores of silver-determinations and hundreds of scorifications and cupellations for gold are often made. Silver, and sometimes gold, is determined in the metallic copper-material by what is commonly known as the combination method, which consists in dissolving both copper and the contained silver in nitric acid, leaving gold as a metallic residue. The silver is re-precipitated in the form of chloride and, with the gold, is separated from the copper solution by filtration. The incineration of the filter, scorification with metallic lead, and cupellation with a subsequent parting of the two precious metals, completes the assay. We have simplified this operation first by the introduction of metallic trays to hold the No. 5 Griffin beakers, thus avoiding handling them either singly or in pairs. The trays, shown in Fig. 1, hold nine beakers, and as soon as the copper has been dissolved the tray may be placed directly on the fire in order to expel the nitrous fumes by boiling the solu-

*The *Journal* is indebted to the American Institute of Mining Engineers for the use of the illustrations to this paper. [Ed.]

After the copper solutions have become cold and the proper quantity of sodium chloride requisite to precipitate all the silver has been added, it is absolutely necessary to stir the mixture in tions. The acids used to dissolve the copper is kept in a five-gallon bottle, having a glass cock, or spigot, with a 0.25 in. orifice, through which the outflow is very rapid. From this bottle the acid is tapped into a specially-designed measuring-cylinder shown in Fig. 2, provided with a stop-cock similar to that of the bottle, which allows the acid to be tapped into the beakers, without dripping, in a neater and cleaner manner than can be done by pouring from a bottle, beaker or cylinder.

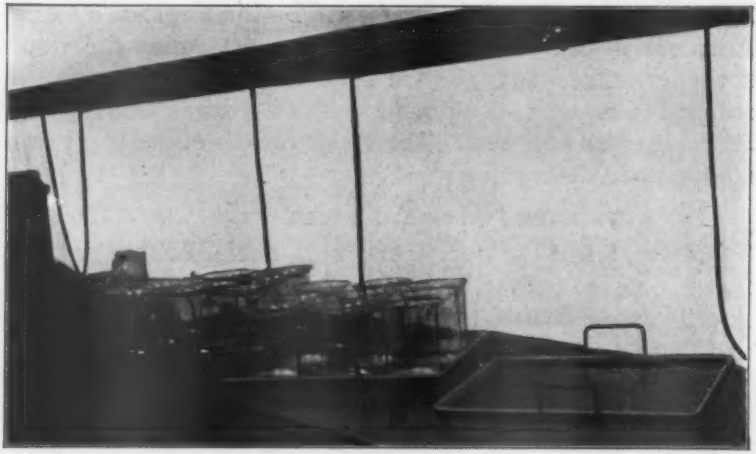

Fig. 1. Metallic trays holding nine No. 5 Griffin beakers.

order that the reaction shall take place throughout, and that, after adequate settling, none of the silver chloride will run through the paper during the subsequent filtration. The stirring of a large number of solutions by hand occupies much time and is very tedious, but omitted, the determination becomes faulty. Figs. 3, 4 and 5 illustrate a stirring-machine which obviates all the difficulties incident to the manual operation of stirring and, by its use ten solutions can be stirred in the same length of time occupied in stirring one by hand, and there is no splashing of solution or breaking of beakers. Fig. 3 shows the machine ready for use; Fig. 4 shows the position after the stir-

ring-rods have been lifted from the solutions and are ready to be rinsed; and Fig. 5, the position assumed after the rods have been rubbed off, the disks holding them and forming a cover to the beakers, now being ready to be washed. This latter operation, however, is generally superflous, for very seldom does any of the solution reach the covers.

Fig. 2. Cylinder for measuring acid.

The characteristics of this stirring-machine are the three based feet, the convenient driving-gear on the right, which admits of the ready application of mechanical power; the slack take-up for the belt on the left; and the rubber disks which hold the rods and form covers to the beakers. The action of the machine is made universal by having several holes in each disk so that the position of the rods will conform to any size of beaker. The separate construction of both beaker-stand and stirring-stand permits a ready change of a set of beakers and allows the rods to remain a permanent part of the whole. Descriptions of stirring-machines are given in some catalogues of manufacturers of chemical apparatus, but they seem to lack the essentials necessary for successful manipulation.

FILTERING APPARATUS.

The construction and operation of our filtering or decanting apparatus are illustrated in Figs. 6, 7 and 8; and by its use twenty filtrations can be performed with perfect ease, and without the least danger of loss by splashing or breakage. The beaker-rack is tilted by means of a hand-wheel on the right, retrograde motion being prevented by a ratchet. The point of

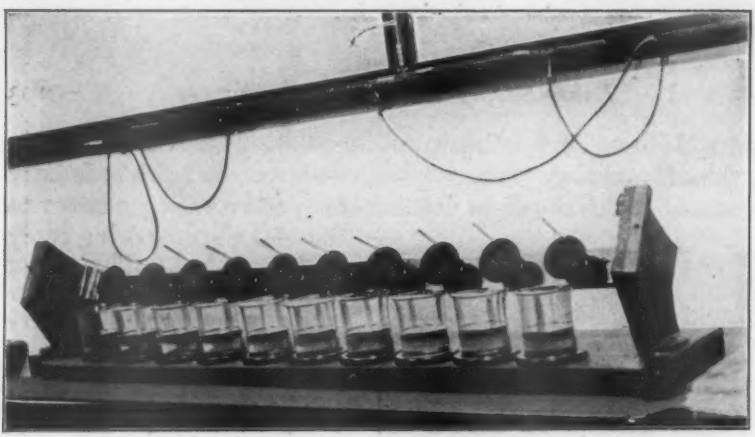

Fig. 3. In position ready for use.

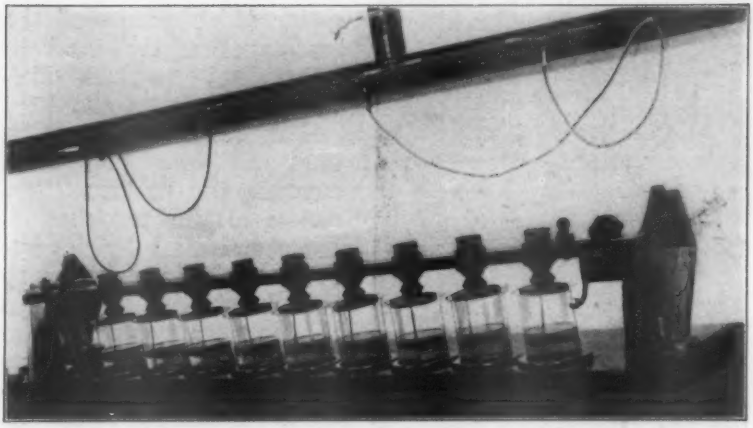

Fig. 4. In position ready for rinsing, after lifting out the stirring-rods.

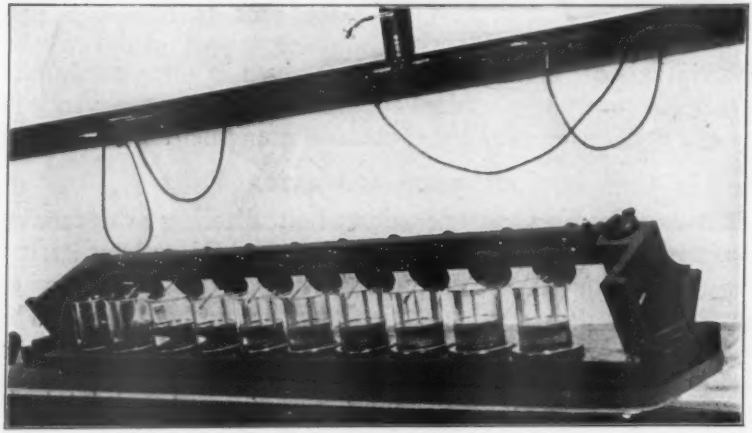

Fig. 5. In position ready for washing off the disks.

THE STIRRING MACHINE.

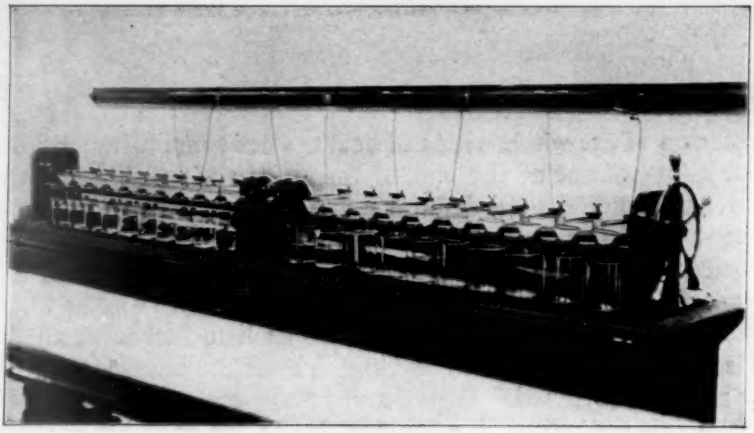

Fig. 6. Original machine, ready to begin filtration or decantation.

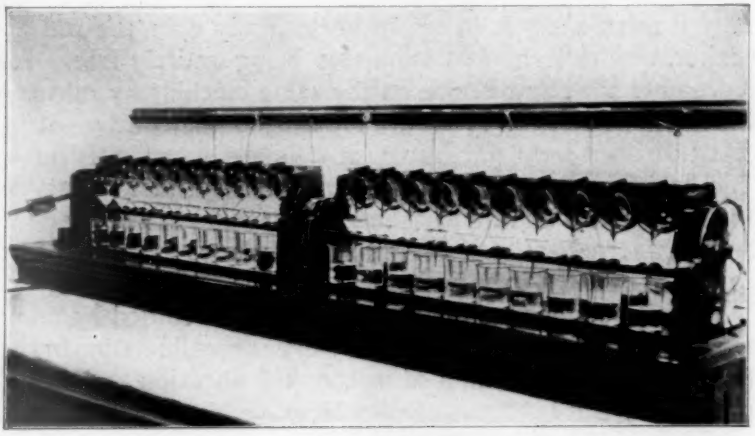

Fig. 7. Original machine, position at end of filtration.

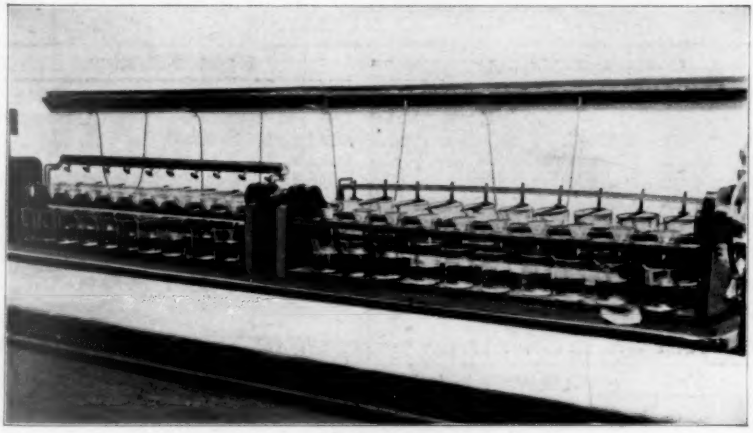

Fig. 8. Original machine with new locking device.

THE FILTERING OR DECANTING APPARATUS.

rotation of the whole series of beakers lies some distance from their lips, about at the end of the glass rods that guide the stream of liquid to a definite point in the filter, an arrangement which is essential for steady pouring. The lifting of the load is aided by a counterpoise on the left. By the use of this apparatus the filtering can be done leisurely with one hand, so steadily that the precipitate remains undisturbed until all the clear liquid is poured off, and the time of the whole operation is greatly shortened. Figs. 6 and 7 show the machine as originally constructed, with a locking-device for each beaker, and rods, consisting of an arm pressed downward by a spring, and free to rotate vertically within an angle sufficient to clamp, as well as to allow it to sweep horizontally over the rod and beaker, the horizontal rotation also being entirely free. Fig. 8 presents a locking-device on the same machine by means of which ten beakers and rods are locked simultaneously. It is a matter of taste which arrangement is the more satisfactory. The beaker-rack and the filter-stand are adjustable to several sizes of beakers and funnels, and the machine can be made for any number of beakers. Light wooden trays are provided to carry the beakers, in sets of ten, to or from the apparatus.

Table I., containing the results of a test recorded by one of my assistants with twenty beakers, shows the difference in time between the new method of mechanical filtration and the old method by hand. The quantity of solution contained in each beaker varied between 275 and 300 c.c.

TABLE I.—COMPARISON OF RESULTS OF MACHINE FILTRATION VS. HAND FILTRATION.

Machine Filtration.			Hand Filtration.		
		Time Consumed.			Time Consumed.
10.21 a.m.	Started.	Minutes.	11.13 a.m.	Started.	Minutes.
10.22 a.m.	Placed rods.....	1	11.14 a.m.	Placed rods.....	1
10.30 a.m.	Finished decanting...	8	11.38 a.m.	Finished decanting...	24
10.41 a.m.	Washed beakers and rods.....	11	11.58 a.m.	Washed beakers and rods	20
10.45 a.m.	Washed filters.....	4	12.04 p.m.	Washed filters	6
10.55 a.m.	Rubbed out beakers..	10	12.13 p.m.	Rubbed out beakers..	9
10.59 a.m.	Folded filters and placed in scorifiers..	4	12.17 p.m.	Folded filters and placed in scorifiers..	4
Total		38	Total		64

Difference in favor of machine, 26 minutes

I have decanted ten beakers, each containing from 275 to 300 c.c. of solution in 4 min. 30 sec., the solutions being run through a double S. & S., No. 597, 12.5 cm. filter.

In connection with the work as just described we have entirely dispensed with the well-known wash-bottle, on account of the unnecessary physical strain involved in its use, as well as its unsanitary character in many instances. The distilled water contained in carboys placed about 4.5 ft. above the floor-level is siphoned into a system of glass-tubing, extending throughout the laboratory wherever the water may be needed. This glass-tubing is provided with numerous "T" connections, to which are attached rubber-tubes, having pinch-cocks and glass nozzles at their ends, which permit the direction of a stream of water to any desired point. The water in the overhead carboys is replenished by forcing a new supply from another carboy in which it has been condensed, placed on a carriage on the floor, up through a glass siphon by means of compressed air.

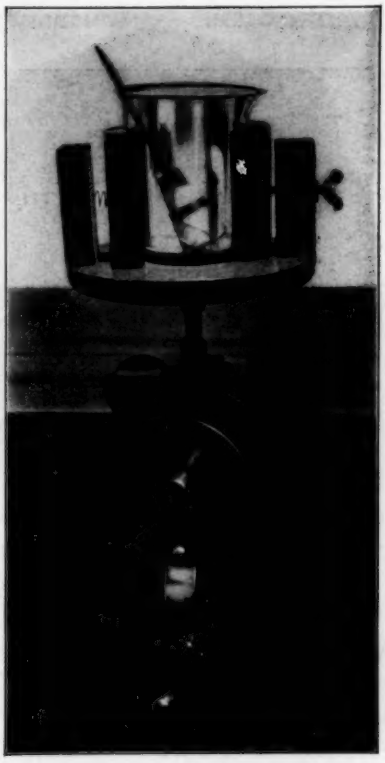

Fig. 9. The "Policeman" in beaker in rotating machine.

When the filtration is complete and the precipitates have been washed out of the beakers the latter must be rubbed out with paper in order to be sure that neither silver chloride nor gold is retained on the walls of the vessels, perhaps by a little oil often contained in the samples, or by the drying and hardening of small particles of chloride above the surface of the solution. In order to facilitate this cleansing, we have designed a machine in which the beakers are rotated. This ma-

chine is on rollers, and runs on rails fastened to the table in front of the filtering-apparatus, and may be locked at any desired point. The rubbing is done by means of a "policeman," Fig. 9, which consists of a rod having a cork fastened at one end, over which is clamped a piece of filter-paper, held in place by a conically-cut ring. The paper thus fastened is run along the bottom and side of the rotating beaker. For each beaker a fresh piece of paper is quickly clamped to the cork.

NEW ASSAY-FURNACE TOOLS.

The implements used in performing the furnace-work in assaying are shown in Fig. 10. A and B are the traditional tongs, universally used for handling singly the scorifiers and the

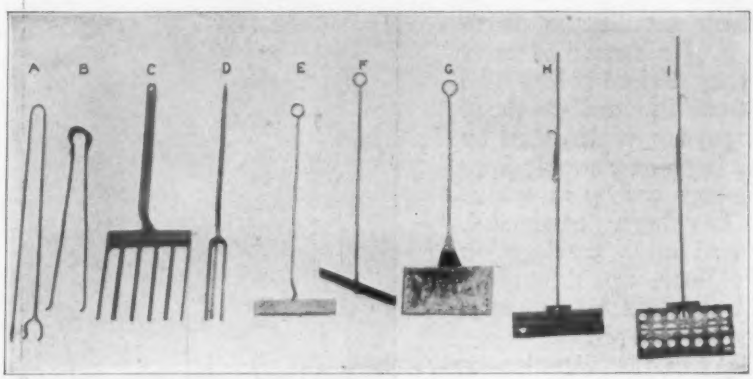

Fig. 10. Furnace tools.

cupels. The former has been entirely replaced with a fork, *C*, with which a set of twenty scorifiers can be handled at one time. In silver-assaying each set of scorifiers is placed in the muffle twice and taken out twice; first put in the muffle for the incineration of the filters, then taken out for the addition of the test-lead, then returned for scorification, and finally taken out for pouring the slag and molten lead into the molds. By the use of the fork, which works perfectly if the muffle be properly supported so that it will not sag to any marked extent, sixty handlings are reduced to three. Four scorifiers constituting a longitudinal row in the muffler are poured at one time by means of a pair of tongs, *D*, and with a little practice the pouring is

made just as easy as with a single scorifier. It is necessary only that the mold correspond to the arrangement of the scorifiers and that the pockets are shallow. The cupels are placed into, or taken from, the muffle in sets of one or more rows, by means of the tools, *E*, *F* and *G*, an idea which, I believe, was first put into practice by my brother, Richard Keller, of Durango, Colo. *E* and *G* are sharp-edged shovels, the latter having up-turned sides. *F* is a rabel, with which the cupels are raked onto the shovel, removed therefrom to the place where they are to be deposited by placing it behind them and withdrawing the shovel. The tool, *H* and *I*, is entirely new, and by its use one or more rows of cupels in the muffle may be charged with the lead-buttons from the scorifiers. Fig. 11 shows the idea of the device more clearly. It comprises a top sliding-plate with openings corresponding exactly to the position of the cupels. The openings in the lower plate correspond exactly with those of the upper one; the plate, however, rests on two adjacent sides

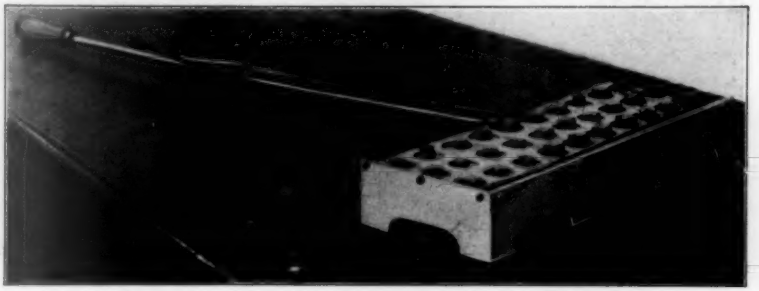

Fig. 11. Device for charging scorifier buttons into cupels.

extending downward at right angles to the plate and to each other, thus forming two closed sides of the instrument; one at the front, and the other at the right-hand side. The height of these sides is such that, when resting on the bottom of the muffle, the bottom plate will be some distance above the cupels and, by a slight pull forward and a push to the left with the handle of the instrument, the set of cupels will be perfectly aligned in both directions, and the apertures in the lower plate will exactly cover the tops of the cupels. The lead-buttons are placed in the apertures of the upper plate and rest on the lower plate before introducing the instrument into the furnace, and

when it is placed over the cupels, which have been properly aligned in the muffle, the upper plate is pushed forward to a stop-point, bringing the apertures of the two plates to register, thus causing the lead-buttons to drop down into the cupels. The handle of the upper plate runs through guides fixed to the handle of the lower plate; both handles are connected by a spring, which acts as a brake when the upper plate is pushed forward to drop the buttons, and also serves to bring it back into its original position, in which the buttons cannot drop through the apertures in the lower plate.

Charles Tookey* first recommended the use of hydrochloric

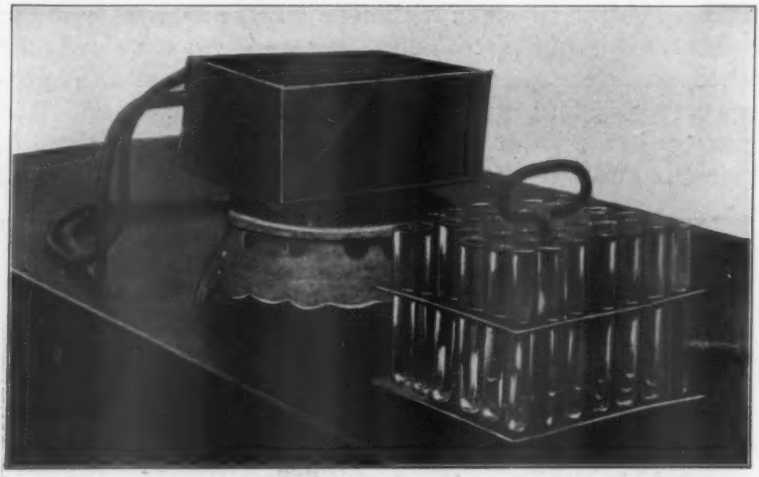

Fig. 12. Convenient parting-bath.

acid (1 HClaq, 2 H_2O) instead of a brush for cleaning the buttons, and for this purpose a small silver dish and tray having perforated pockets give excellent satisfaction. By the use of this device fifty or more beads at a time can be treated, washed and dried without transfer.

Fig. 12 shows a very handy parting-bath; which, though old in principle, has not been in general use. The vessel is a constant-level water-bath and the tray an ordinary test-tube holder. The silver beads to be parted are dropped into the

Journal of the Chemical Society (London), vol. xxiii., p. 366 (1870).

test-tubes, and the latter filled with dilute nitric acid of a strength of one of acid (sp. gr. 1.42) to 9 of water. The water in the bath is first brought to the boiling point before the tray with its contents is set into it. Treated in this way the gold almost invariably remains in the form of a small coherent bead, even from an alloy as low as one part of gold to 500 of silver.

I have recognized that the system of handling everything in sets was incomplete as long as I was unable to take a whole set (twenty) of scorifiers from the muffle and pour their contents simultaneously into the molds. Recently a tool for that purpose, shown in Figs. 13 and 14, has been perfected. It is composed of quintuple tongs, corresponding to the five longitudinal rows of scorifiers in the muffle. The lower part of each pair

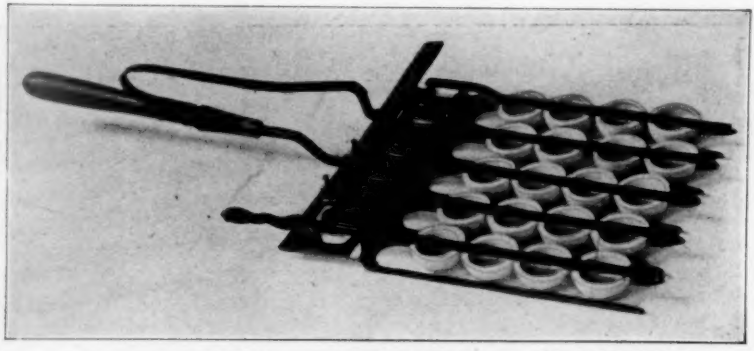

Fig. 13. Multiple tongs; Scorifiers in position for removal from furnace.

of the tongs consists of a fork, on which the scorifiers rest, and one of whose prongs is retilinearly extended through two bearings in a frame, and held in position by collars. This extension is free to revolve in the bearings, and it is the axis of rotation of the tongs. To each of them is attached, at right angles, a lever, extending upward at an angle of 45°, and all the levers are connected by slotted joints to a cross-rod. Therefore, if by means of a crank, fastened to the end of one of the extended prongs, one of the forks is turned and the scorifiers tilted to the desired angle, the others performing the same rotation. The center of gravity of the scorifiers lies to one side of the rotation-point, and they would therefore, on being lifted, tilt in that direction; this, however, being prevented by the cross-bar resting

against a post at that end of the frame toward which the inclination tends.

The scorifiers are clutched by the upper prong of the tongs, which is fastened to a spring on a post of the fork below, and which is free to move in a vertical plane; the pivotal point lying over the spring and post. By bringing pressure on the extended ends of these clutch-bars behind the pivot, their other end will rise from above the scorifiers, and thus release these, or permit the placing of them onto the tongs. The pressure exerted on the rear ends of the clutches is accomplished by means of a cross-bar fastened to a spring-bar, which is itself riveted to the handle of the instrument; all of which may be plainly discerned in the illustrations. In pouring the contents of the

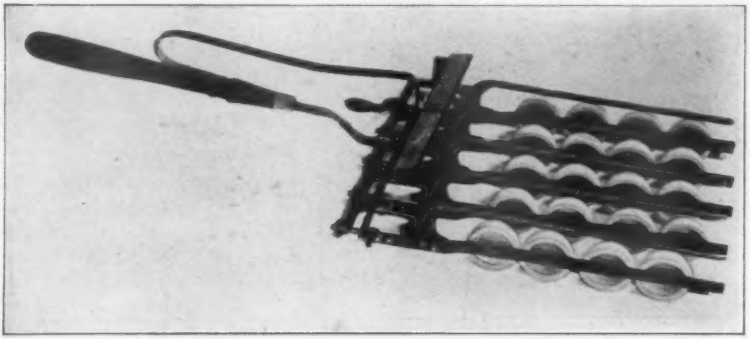

Fig. 14. Multiple tongs; Scorifiers tipped for pouring contents.

scorifiers, the frame of the tool rests on the edge of the mold, leaving the tongs free to turn.

The introduction of the new system of manipulation described in this paper has resulted in economy in several ways. Much labor has been saved; breakage of expensive glass-ware has been very largely eliminated; and the time of the furnace-work, and, consequently, the consumption of gas, have been much reduced. Furthermore, the gain has been a moral one, and work formerly regarded as tedious has become more of a pleasure; especially has the sojourn in the furnace-room during the hot summer months been rendered cooler by being greatly shortened.

The appliances described in this paper may eliminate the

laboratory boy, but if not, they will make him more reliable. They also increase enormously the quantity of chemical work that one man can do in a day. In the small domain of our laboratory the change from the old system to the new is considered to bear about the same relation as the change from ancient horse-cars to the modern rapid transit.

In conclusion, I take pleasure in acknowledging the efficient callaboration of my assistants, Mr. Albert Ferrell and Mr. K. W. McComas, the former having shown himself particularly useful as a skilled mechanic in the construction of various improvements.

CAUSE OF FAILURE OF BOILER FURNACES.

The collapsing of boiler furnaces is almost always the direct result of scale or of oil in the feed water, the latter being a particularly prolific source of trouble, according to a recent paper before the Northeast Coast Institution of Engineers. No ordinary furnace fails for lack of strength if clean and covered with clean water. A very thin smear of oil, however, has an effect totally out of proportion to what might be expected. In a furnace having a normal factor of safety of five, this factor rapidly decreases after the temperature reaches 650 degrees F., and entirely vanishes at a red heat. Steam at a pressure of 200 pounds has a temperature of about 380 degrees, or 270 below the point at which the tenacity of the steel begins to be affected, but a clean furnace, rubbed over with a very clean and thin coat of mineral oil, will soon rise above 650 degrees, even under light duty, and often reach 1200 degrees, at which point 75 per cent. of the strength has departed. With the use of high-grade mineral oils the danger is less than with low-grade oils, due to the fact that the latter emulsify and hence cannot be removed from the feed water except by chemical treatment.

PHYSICAL PROPERTIES OF TANTALUM.

Warner v. Bolton in the *Zeit. f. Elektrochem*, 1905, pp. 503-504, gives details of tests upon the hardness of tantalum in the purest form that has yet been obtained. The results obtained show that tantalum, containing only very small amounts of oxide as impurity, after hammering into sheets at a red heat, is equal in hardness to the best and most carefully finished steel. Tantalum, however, greatly exceeds this hard steel in toughness,, for while these hard tool steels are brittle, tantalum can be rolled into sheets without injury. The new metal in its purest state, combines the hardness of the best steel with a greater toughness and ductility than is known to be possessed by any other metal.— *Eng. and Min. Jour.*

THE ZUNI SALT DEPOSITS, NEW MEXICO.

Forty miles south of the pueblo of Zuni, in the west-central portion of New Mexico, there is a deposit of salt which is not only of great geologic interest, but promises to prove of considerable economic importance. It is briefly described by Mr. N. H. Darton in the year-book of the United States Geological Survey, which is entitled "Constitutions of Economic Geology, 1904."

The location is eighty miles south of Gallup, on the main line of the Santa Fe Railroad, and about the same distance west of Magdalena, on a branch of the same railroad system. This deposit has been a source of supply for the Indians and Mexicans for several centuries, and of late the salt is hauled to ranches in a wide surrounding district. The present output averages only approximately 1000 tons a year, valued at about $2.50 a ton. A small colony of Mexicans at the locality collect the salt in a very crude manner. Ordinarily, persons desiring a supply go to the place and help themselves.

The deposits occur in a lake, which occupies a portion of the bottom of a deep depression in a plain of Cretaceous sandstone. This depression is about a mile in diameter, and has walls of sandstone, in part capped by lava, averaging about 150 feet in height. The lake is about 4000 feet long, east and west, and about 3000 feet wide, and is apparently shallow. The water contains about twenty-six per cent salt, mostly chloride of sodium. The region is arid and the evaporation causes the crystallization of the salt, especially in the shallow water.

A large amount of salt could be obtained by properly conducting solar evaporation of the lake water. By washing the salt with a small amount of the lake water the more soluble foreign salts are removed and almost pure chloride of sodium remains.

FORCED DRAFT.

Forced draft appeared some years ago in danger of being abandoned for all ordinary work because of frequent complaints regarding its effects in burning our the grates, injuring the boilers and blowing gas and smoke from the fire doors into the fire room. It has since been demonstrated that these difficulties were due to the fans being too small for their work, requiring them to be operated at far above their normal speed. This caused an ash-pit pressure of from five to ten inches of water where only ¾ to 1¼ inches is required. Later and more accurate knowledge regarding the proper application of the fan blower for this purpose has resulted in restoring the system to its former measure of popularity. When it is used the air passing from the ash pit to the combustion chamber is greatly reduced in pressure, due to the resistance of the grates and fuel, while the stack tends to create a partial vacuum in the furnace It is thus impossible to maintain more than a slight excess of pressure in the combustion chamber and this should not be forced, as was formerly the case.—*Iron Age.*

The Problem of Gravitation.*

By Charles Morris.

Of the varied problems with which modern science has had to deal, that of gravitation has proven the most difficult to solve. While nearly every other agency of nature has in some measure yielded up its secret, as regards this, apparently the most universal of them all, we remain almost completely in the dark. The scope of the problem has been somewhat narrowed, but this is all that can be said. Physicists are satisfied that attraction is but a name for something else, that "action at a distance" does not exist, that some agency unknown is at work upon matter, and even surmise that this agent may be the luminiferous ether. But there they stop, in ignorance of how this agent operates, or how it produces its effect.

It is certainly very probable, in view of the universality of the force of gravitation, that it is dependent upon some simple principle, and possibly this simplicity is the chief cause of its elusive character. There is so little to take hold of, such a lack of those varied elements of action which aid us elsewhere. If, indeed, we could accept attraction as the actual force which many believe it to be, there would be no problem. Newton's law of gravitative action is based on the proposition that every atom in the universe attracts every other atom; the force of attraction being inversely proportional to the square of distance. But Newton accepted attraction only provisionally; as a convenient working tool, not as a credible fact. He expressly says:

"That gravity should be innate, inherent, and essential to matter, so that one body can act upon another at a distance, through a vacuum, without the medium of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I be-

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lieve no man, who has in philosophical matters a competent faculty of thinking, can ever fall into it."

This view of the impossibility of "action at a distance" is widely held by physicists to-day. It is unthinkable to the logical mind that one substance can act upon another through a void, or through space occupied by material that takes no part in the action; as, for an extreme instance, an atom in the sun exercising a pulling force upon one in the earth, by virtue solely of some property dwelling within itself. Recognizing this conclusion as a finality, no matter haw small may be the interval between the atoms, all scientists who have attempted to explain gravitation have done so on the basis that the seeming attraction is due to the agency of an external medium, acting through some system of impact, pressure, or tension, stress or strain.

Various hypotheses have been offered in pursuance of this view. In some the active medium is the luminiferous ether; in others it is a special ether confined to this duty alone. Newton suggested the agency of a special medium in some way rarified by material substances, the rarity decreasing outwardly in due proportion to distance. Le Sage invented a system of "ultra-mundane corpuscles," flying in all directions through the universe, impinging forcibly upon the spheres and moving them towards each other. Lord Kelvin imagined an incompressible fluid, filling all space, flowing in from infinity and absorbed by each particle, or momentarily created in each particle and flowing outward to infinity. It is not necessary to go into the details of these hypotheses, or any one demanding a special ether, for none of them is to-day accepted. The tendency now is to look upon the luminiferous ether as in some way the agent at work in gravitation; but in what way remains unknown. A considerable number of hypotheses have been offered in the past few centuries in which gravitation is ascribed to some action of this ether, some of them quite ingenious, but few of these attained even momentary acceptance and none of them is now considered of any potency.

Such is the status of the gravitation problem as it exists to-day. Its scope, as above said, has been narrowed. Gravitative force is believed to be due to some agency of the ether, but

this is as far as anyone has gone. All efforts to show in what this agency consists have failed. This is all, but must it remain all? Is there no clue to the labyrinth? May it not be that the failure so far is the result of a radically false conception of the scope of the problem? Has science put the real nature of the question at issue before it; studied its initial elements before seeking to reach its solution? May not one source of error be the following? In popular acceptation matter, acting through the force of attraction, is the sole active agent in gravitation. In scientific acceptation the ether, or some other universal substance, is the sole active agent. There is no hypothesis in which the possible agency of both matter and ether, each taking a direct part in the issue, is considered. Yet may it not be that matter and ether are jointly active in the process, and that the seeming attraction is the result of conditions of energy directly interacting between these two elements of nature?

Again, gravitation appears to many to stand apart; to have no traceable relation, direct or indirect, with the other forces; to be an isolated phenomenon, which must be dealt with by itself. It is, no doubt, maintained by scientists that all the forces of nature are interrelated, and some hold that there is a close affinity between gravitation and magnetism, but no one has succeeded in demonstrating the existence of such a relation, and so far as we actually know the gravitative force is isolated. Thus the case stands at present; but few physicists doubt that this universal force is definitely related to the other forces of nature, and efforts to find the line of connection have often been made. That they have been so far unsuccessful is no evidence that such a connection does not exist, in view of our ignorance of many of the underlying principles and conditions of nature.

In dealing with the subject of attraction it must be premised that it is not confined to gravitation, but exists also in magnetic, electric, and chemical action. Instead of being a single, it is, in reality, a four-fold phenomenon. But this by no means indicates that there are four separate attractions, unlike the origin and character. Such an idea would infinitely complicate the problem. A single attraction is difficult enough; four undelated forms of attraction would be insuperable. The force we call attraction is in all probability single and simple; an unique phenomenon, not a

composite enigma. That variation in force and method of attraction may arise from variation in conditions is easy to understand; that it arises from primary differences in the force itself is infinitely less probable. We certainly cannot admit this of a peculiar force like attraction unless it be proved that the diversities in its manifestation are irreconcilable. Yet if we view all displays of attraction as due to one general couse, the fact becomes important that attraction does not constitute all we know of electricity and magnetism, as it does in the case of gravitation. Attraction, for instance, is but one among many electric phenomena. It appears to be a temporary one, subject to passing conditions, and a survey of these conditions may throw some light upon the hitherto sealed mystery of gravitation. The path to the unknown leads through the gateway of the known. It is a path that seems never to have been trodden in the present inquiry, but it is one well worth traversing.

It certainly seems a judicious course to study the problem of gravitation at a distance, beginning with the somewhat transparent electric attraction and leading up to the opaque gravitative attraction. This work has been largely done for us in the case of electricity, though no one has carried the effect there visible into the domain of gravitation. A cursory examination of electric attraction seems to render it evident that, in this case at least, attraction does not manifest itself as an inherent property of matter. It comes and goes in response to changes in conditions, and apparently without regard to the matter involved. It may even be transformed into the opposite force of repulsion by a simple reversal of conditions.

We are not aware of what takes place in static electricity, other than that attraction and repulsion appear when the electric state is produced and disappear when electricity is neutralized or conducted away. In current electricity we can with some ease discover a general principle of action. Let us take two metallic wires placed in general parallelism at a moderate distance apart. They do not apparently affect each other. Their gravitative force is too slight to yield any visible result. But if we send currents of electricity through them in the same direction a marked effect appears. They show a tendency to approach, to move together. In common parlance we say that

they attract each other—the seeming attraction aroused being far more powerful than that of gravitation. Reverse one of these currents, cause them to flow in opposite directions, and a new force manifestation appears, that of repulsion. The wires show a tendency to move apart. Cut off the currents and the wires return to the passive state. Every visible indication of attraction of repulsion in them disappears.

We have here a very significant fact in any study of the cause of attractive force. Electric currents seem capable of generating attraction when they move in parallel or accordant directions and repulsion when their directions are reversed. As these forces disappear when the currents are cut off, they may be looked upon as in some way generated by these currents, the part taken in them by matter being, so far as appears, confined to its power of conducting electricity.

It is well to say here that exact parallalism in the conducting wires is by no means necessary, it being simply requisite that the currents should have a general consonance in direction. If the wires form an angle, starting from a common point, and both currents move toward or from this point, attraction will appaers, no matter how wide the angle, even if it be a broadly obtuse one. On the other hand, if one current moves toward, the other from, such an angular point, the wires will repel each other without regard to the width of the angle. The tendency will be to bring the wires into parallel positions and then to draw them together or force them apart as the relations of the currents may demand. All that is requisite in the one case is accordance, in the other discordance, in the direction of the currents.

In seeking to deduce a definite conclusion from these facts, let us take the most recent theory of electricity. This is, that the current is conveyed by electrons the minute constituents of atoms, which fly with extraordinary rapidity from atom to atom, so that practically a swift stream of them flows through the wire. If this theory is correct it gives us some warrant to conclude that attraction and repulsion are dependent upon, not matter in itself, but matter in motion. These forces seem to be in some way generated by moving matter, or movement in matter, attraction by parallel or accordant motions, repulsion by reverse or discordant motions.

The phenomena of magnetism leads us to a similar conclusion. In fact, the magnet can be exactly imitated by sending an electric current through a spirally-wound wire. Two such wires act like two magnets, attracting and repelling, displaying north and south poles. The results are the same as when straight wires are used, the coils attract when their spiral currents flow in parallel directions, repel when their directions are reversed. These electric phenomena are so significant of what is taking place in the interior of magnets that they have led to Ampere's theory, everywhere accepted, that every particle of a magnet has closed currents flowing round it in fixed directions, and that to these currents its attractive and repulsive forces are due. Without going into the details of the magnetic phenomena, the one point with which we are here concerned is that magnetic attraction, like electric, gives very strong indications of being a function of matter in motion, not of matter in itself.

What conclusions shall we draw from all this? While we are ignorant of what takes place in static electricity or in chemical action, the facts of dynamic electricity and of magnetism lead irresistably to the inference that attraction is not an inherent property of matter. It is dependent upon special conditions, and these conditions can be readily so changed that attraction will disappear or will be replaced by repulsion, with no evident change whatever in the character or position of the matter concerned. The one thing necessary for the display of these forces, so far as appears, is the development of special conditions of motion in the material employed.

Here is a fact of extraordinary significance, and one we must take into account in dealing with attraction in any of its manifatesitons, general and local alike. It is, stated broadly, that attraction is not a property of matter in itself, but arises from a special condition of matter, this condition appearing to be that of motion—not an irregular and constantly reversed motion like that of heat, but a motion in fixed directions, as in the electric current. This inference seems to hold good whether or not we accept the recent theory of electricity. The current may not be due to the motion of electrons, but few doubt that in electric conduction motion of some kind and in some material is taking place, and the appearance of attraction or repulsion seems immediately dependent upon this motion. The

query naturally arises, is gravitative attraction similarly conditioned? Is motion in spheral matter necessary for its manifestation?

This is certainly a very probable conclusion, far more probable than the opposite, that attraction is due to more than one cause and dependent upon more than one condition in matter. It is difficult to imagine that there can be two or more separate causes for so mysterious a force. On the other hand, the condition predicated as necessary is existent in all spheral matter. Motion is everywhere present. The earth, for instance, is circling around the sun at the extraordinary speed of more than eighteen miles a second, and through general space, in company with the whole solar system, at a speed of twelve or more miles per second. The same is true of all spheral bodies, many of them moving with a far greater speed than that named. If now, instead of looking upon the earth as a unit, we regard it as a vast collection of independent atoms, it becomes evident that all its contiguous atoms are rushing in parallel lines with immense rapidity through space. Thus the condition which seems requisite to attraction in local instances is present in the spheres, and we have some justification in assuming that it may be the exciting cause of attraction there also.

To return now to the view so widely entertained, that the luminiferous ether is the active agent in what we call attractive force, let us recall what was above affirmed, that attraction may not be a result of the action of either matter or ether considered separately, but may arise from a close interaction between the two, each playing its part in the result. As to the part taken by matter, we have indications of it in electric and magnetic action. It remains to try if we can discover and coördinate or resultant action in ether.

As a preliminary, something must be said about the nature and conditions of ether, so far as known or conjectured. It is held to be an universal substance, occupying all open space and penetrating all the spheres. It is possibly the basis of matter itself, since each atom may be an ether aggregate. Whether it is composed of particles or consists of substance in a state of infinite division; whether it is a plenum, filling all space absolutely, or permits of void intervals; whether it is compressible or incompressible, are questions unanswered, perhaps un-

answerable. We do not know if cohesion exists within it, for the pressure of a plenum may produce the effect of cohesion. We know, from the phenomena of light and other radiations, that it is capable of transmitting vibrations in extraordinary variety and complexity. And the phenomena of light have given rise to the hypothesis that the ether is an electric solid, it being maintained that only a solid could transmit the transverse vibrations of light. To explain the passage of the spheres through solid ether without obstruction the example of an ordinary jelly is adduced. As a weight will sink through a jelly and leave no trace of its passage, so it is held that the spheres can pass freely through the almost infinitely thin jelly of the ether. But the weight does not pass through the jelly without obstruction. Its speed of fall is retarded, and it is hard to avoid the conclusion that the spheres would be similarly retarded by the ether, however thin, if it have such a constitution as here conjectured. Certainly this hypothesis does not appeal to us as probable, however necessary physicists may deem it, and we have before us a problem of very difficult aspect.

We know nothing about the innate constitution of the ether, but from its remarkable readiness to vibrate in response to material impulses we may deduce that it is highly mobile, and are justified in conjecturing that it is a reservoir of intense motor energies and capable of exerting vigorous pressure if these energies are brought to act in one direction. The belief that matter may be derived from the ether is an argument to this effect, since the energies of the ether would then be the source of the very active motions possessed by matter, while energy may be retained much in excess of that given. There are other problems connected with the ether. For instance, is it quiescent or is it adrift through space? Have its particles onward movement or only vibratory or other local motions? This problem is unanswerable, but for our purpose it is simply necessary that the ether should be a storehouse of potent energies.

Returning now to the subject of the relations between ether and matter, it may be said that it has long been a vexed problem how the earth could rush at its immense speed through the ether without obstruction. It was formerly supposed that the earth dashed the ether aside in vast eddies as a ship does the ocean waves. It is now believed that the earth is readily per-

meable to ether, which fills its innumerable pores and drifts through it almost as freely as though no matter were present. But this view merely leaves us confronted with the same problem in a different form. It is simply transferred from the earth as a whole to its constituent atoms. The transfer of the problem from earth to atoms does not change the probable result. The question of obstruction remains the same. The difficulty seems an insuperable one if we hold that the ether is a solid. It is a very awkward one even if we hold that it is an almost infinitely thin gas, especially if this gas be a reservoir of intense energies.

We have now reached a critical point in our inquiry. The problem before us assumes a triple aspect. Does the ether oppose and obstruct the atoms in their swift movement? Does it yield and flow past with no effect upon them? Or does it react upon them in a way differing from that of obstruction? The first of these seems the most probable, but all the evidence goes to prove that it does not exist. The second, while possible, does not appeal to us as probable. The third is a new point of view, never yet taken, but one of great interest, since it may possibly be the missing element in gravitation.

Let us consider the case of a group of atoms moving at a speed of eighteen miles per second through a mass of quiescent but highly mobile ether. In view of the fact that the atoms appear to move without obstruction, we might predict that the ether is non-coherent and therefore non-resistant, and is dashed aside in a broad eddying whirl, curving backward so instantaneously that the atom group is past before its internal energies are brought into play. But the atom group is no more solid than is the earth. It is permeated everywhere with pores, through each of which the ether will drift backward. But if the formation of the ether is disturbed and an eddying movement is produced, it seems probable that it would flow backward more freely outside the group than through its pores, and more freely through its larger than its smaller pores. In other words, if there is a disturbance of the ether formation and interference with its drift through the atom pores, this interference increasing as the pores grow more minute, we should have a degree of rarefac-

tion in these pores, a partial ether vacuum growing more declared as the pores decrease in size. The natural result from this would be a pressure of the external ether similar to that seen when an air vacuum is produced.

The point to be made is this:—If the ether, despite its internal energies, makes no frontal attack upon the atoms, but flows back in unresisting eddies, seeking in preference the larger channels, it seems fair to presume that it may make a lateral attack, crowding the atoms into the spaces in which there is a partial ether vacuum. This is the crux of the situation. If the whirling ether reacts laterally instead of frontally, forcing the atoms inward instead of backward, we are led to an explanation of two mysteries, that of the lack of obstruction to the motion of the spheres and that of the pressure of gravitation. The conceivable former is converted into the actual latter. If the possibility of this be admitted, all forms of attraction will be brought into conformity, that of gravitation coming into harmony with those of magnetism and electricity, to the extent that the motion of matter in each case is the instigating cause.

Such an inward pressure in ether of course would produce condensation, and it might be imagined that the atoms would be driven together until the spaces between them were obliterated and vacuus intervals become impossible. But the atoms have other motions than their spheral ones. Their heat agitation exerts an energy sufficient to keep them permanently apart, despite the gravitative force, and the degree of separation in any case would be the resultant of the opposing forces of external pressure and internal energy.

There is a variation in results between the cases of the movement of a body through air and of a body through ether. The resistance in the former case is due to the cohesion of the air particles. However feeble this be, it would seem likely to cause some resistance, and we know that such a resistance takes place to the motion of meteorites in the exceedingly rare upper atmosphere. The fact, then, that ether makes no resistance seems to indicate that, as above suggested, it is quite destitute of the condition known as cohesion. Its mission may be to produce in other matter the cohesion it lacks in itself.

If there be such a non-coherence, this may be the explanation of its non-sisistance to moving matter; while its internal energies, and its rarefaction in the pores of moving matter, may be the explanation of the compressing pressure known as attraction of gravitation.

So far we have dealt merely with atom groups and with the very slight pressure exerted upon each of these. Let us now consider the effect upon the sphere as a whole. Its innumerable swarm of atoms, each yielding a minute effect, must in the aggregate yield an immense effect. If the vacua produced in each group of atoms gives rise to an inflow of ether reaching beyond the immediate vicinity, or a pressure making its effect felt for a slight distance outward, then the whole ether impulse would presumably extend to a great distance outward from the earth, the ether moving inward or its energies being directed inward toward the earth throughout a broad field of space. If gravitation is due to this cause, the ether action must extend to and far beyond the sun. In the case of the latter it is supposed to extend to the fixed stars.

In the LeSage hypothesis it is held that the earth and the sun exert an indirect or "shadowing" influence upon each other, each cutting off a part of the stream of corpuscles moving upon the other. The result is held to be a diminished pressure in their connecting line, with the result that the external pressure is the stronger, the effect being to force them toward one another. In the case of an ether pressure, such as we have suggested, the same result would appear. But the present hypothesis suggests a different agency, which may be of still greater effect. The ether between the sun and the earth would be affected by opposing influences and would tend to move in both directions, vigorously toward the sun, more feebly toward the earth. Thus its action toward each orb is resisted by the other and is thus greatly diminished. There must be a limiting zone in which there would be a balance between these tendencies and the ether fail to exert energy in either direction. In this zone the ether, seeking to act in both directions, would tend to thin out or become rarified, a partial vacuum being produced into which both spheres would be forcibly driven by the external pressure. Thus the cutting off of the pressing force of ether from each sphere by the other, thus immensely reduc-

ing its range of action in this line, and the rarefaction of ether between them, would form a double agency forcing them together and holding them in mutual relations of position. If this be the case, the influence of a vacuum must be the active agency not only between atom and atom, but between earth and sun, and perhaps between distant orbs of space.

If the present hypothesis is based on correct premises, and gravitation is a result of the action of moving matter upon ether and the reaction of ether upon matter, there is a very interesting deduction to be made. This is that the force of gravitation must be dependent not upon mass only, as in the Newtonian theory, but upon mass and rapidity of motion combined. For it seems a just conclusion that if the motion of atom groups causes rarefaction of ether within their pores and resultant ether pressure, the rarefaction must increase with increase of speed, and the pressure be correspondingly enhanced. In other words, the force of gravitation bust increase with increase of speed in spheral bodies, and the rapidity with which suns and planets move through space would become an important factor in their force of attraction or gravitative energy.

Thus the gravitative force of each planet of our system toward the sun may be dependent only partly upon its mass and largely upon its speed of motion in its orbit. If this be the case, calculations of the mass of a planet based solely upon its gravitative force may be radically false. The same principle would hold good for the great orbs of space. In the case of the extremely swift star known as 1830 Groombridge, the speed of which may be more than two hundred miles per second, there would, under this hypothesis, be a very marked increase in gravity. It is held that such orbs as these have an energy of motion too great for the restraining power of all the orbs in the universe. But if their force of gravity increases with their rate of speed they may be held captive despite their plunging energy. The effect of speed upon gravity is offered here as a suggestion only. It will appear more in the light of a fact when we return to the consideration of electric and magnetic attraction.

There are some minor suggestions to be offered. While the view has been taken that the gravitation of the planets toward the sun depends upon their orbital speed, it must also be re-

membered that the sun and its attendant planets are rushing together through space with a speed estimated at twelve or more miles per second. While this may mainly affect the astral relation of the sun, it may also affect the gravitative energy of the planets and of their satellites. There remains to be considered the axial revolution of the planets. In this the atoms move in parallel lines which should have some gravitative effect. This effect we seem to find in their magnetic energy. The earth, in this way, may be converted into a great magnet, with an energy dependent upon its rotatory speed. If such is the case, each orb of the universe is brought into close analogy with the atom magnet, with its circling motions. The sun, whose equatorial speed or rotation is about four times that of the earth, may possess a much more powerful magnetic force, sufficient, perhaps, to affect some of the planets.

The hypothesis here advanced is not in agreement with the view that the ether is a solid mass. Solidity would require that the ether should possess a force of attraction within itself, a condition which would infinitely complicate the problem of gravitation. The doctrine of ether solidity is based on the fact that the irregular agitation of the particles of a gas would destroy or dissipate transverse vibrations like those of light. But may there not be a condition even of a gaseous ether in which this irregular agitation would not exist sufficiently to disturb the vibrations of light? Under the hypothesis here advanced the ether, even if a very rare gas, would seem to be controlled in its movements, these, instead of being irregular and desultory, being in straight lines toward the spheres; its corpuscles, if such exist, being as rigidly controlled in their movements as though it were a solid mass. Being drawn constantly inward toward the spheres by the vacua existing within them, exerting its pressure, and then drifting away as the spheres pass onward, its movements would be, at least in considerable measure, regular in character, and while not a solid in fact, it might be so in effect. Lines of radiant vibration from sphere to sphere would traverse an ether setting steadily toward these spheres, and the ordinary irregular agitation of gaseous atoms be overcome by the directing and controlling agency here indicated. This would be especially the case if the pressure toward the spheres should give rise to a subsidary pressure at right

angles to this line of action, the whole body of ether being thus set in motion and controlled in its movements by the one unceasing cause. It is not here intended to maintain that the effect here predicated would be complete, or even large, at a great distance from the sphere, but it may be that even a partial repression of irregular atom motions might suffice to permit the conveyance of light undulations.

Returning to the local forms of attraction, which furnished the clue followed in our study of the spheres, we may seek to apply the hypothesis advanced to these local conditions The movement of the electric current is now thought to be due to the flight of electrons, passing with immense swiftness from atom to atom, the effect being the same as if a multitude of electrons darted side by side through the whole length of the wire. Here we have to do with a motion of material particles in parallel lines, as in the case of the spheres, and while the electrons are far more minute than atoms, their speed is enormously greater, approximating the extraordinary speed of light. They should therefore profoundly disturb the ether through which they move and produce an ether pressure of far greater energy than that of gravitation. This may be the explanation of the fact that the attraction of two wires conveying electric currents so greatly exceeds the attraction of gravitation between these wires.

In magnetic attraction we have much reason to believe that matter in motion is the agency concerned. The helix, with its current, is simply an artificial magnet, and gives abundant warrant for the Amperian theory that each atom is a minute magnet, its energy being due to closed currents circulating around it, as currents of electricity circulate around the circular curves of the helix. In Ampere's day it was impossible to say more. The theory of the atom then entertained gave no clue to the character of these currents. We can now go much farther. In the recent theory of the atom we have to do with a large number of minute particles, which make up the atom-mass and move with an extraordinary rapidity, their speed being brobably many thousands of miles per second. Their mode of motion is unknown, but if we conjecture it to be a circular one, we would have in it the counterpart of Ampere's closed currents. In this case we would possess in each atom an analogue of the

rotating sphere, with its axis and poles and its magnetic force, and the movement of the rotating electrons which make up the atom through the ether in which they float, might well produce pressure like that due to the electric current in the wires, or the atom motions in the spheres. Their immense rapidity would serve to explain the great force of magnetic attraction.

In dealing with electric and magnetic forces we have the phenomena of repulsion as well as that of attraction to consider. How shall this force be explained? While electric attraction demands parallel or accordant currents, repulsion follows reversal of currents, and if the former produces ether rarefaction between the conducting wires, may not the latter produce ether compression? The ether whirls produced by the speeding electrons would meet from opposite directions and tend to heap or condense, exerting a pressure outward in their resumption of normal conditions. In magnetic action the same state of affairs may be looked for. When like poles are brought together their currents of atomic motion would sweep round in opposite directions and the ether whirls to which they gave rise meet in opposition, heaping up and forcibly expanding, thus forcing the magnets apart.

Does a similar force of repulsion act between spheres? It well might do so in the case of the requisite conditions between two spheres. If, for instance, two spheres pass each other in apposite directions, repulsion would be likely, under our hypothesis, to result, if they were close enough together to produce conflicting ether whirls between them. This, however, is a matter upon which it is not safe to decide.

Of the hypothesis here presented it may be said in conclusion that it fulfills the conditions of being simple in principle and universal in operation. Its cause is an unceasing one, since matter and motion are co-eternal verities and ether everywhere present and active. All the substantial contents of the universe are concerned in it, matter and ether alike it depending upon a simple interaction between these two constituents of nature. If the action of the ether suggested be an admissible one all else follows. If it is inadmissible, for any sufficient reason, the whole argument falls to the ground.

ORIGIN OF SOUTH AFRICA DIAMONDS.

An interesting paper on "The Diamond Pipes and Fissures of South Africa" was recently read before the British Association by H. S. Harger. The author considers that the age of the Orange River Colony pipes is Triassic (late) or Jurassic, and that the Pretoria pipes are contemporaneous. "They are," he said, "the latest eruptives of South Africa." The origin of the blue ground in the pipes he considers due to the sheltering of the ultra basic rocks, such as eclogite, pyroxenite and lherzolite, all of which are commonly met with and are made up of the minerals which form the bulk of the blue ground. In these rocks garnet occurs plentifully and also olivine and pyroxene. The diamond has frequently been found crystallized in garnet and more rarely in olivine; hence the gem must have had its genesis in the ultra-basic zone in which those minerals originated. The experiments of Crookes and Moissan suggest that the presence of iron was necessary for the formation of the diamond; but to this Mr. Harger objected, owing to the fact that the necessary iron does not exist in the diamond mines and also because Dr. Friedlander's experiments proved that diamonds can be formed in olivine without the enormous pressure and heat aimed at by other experimentalists. In conclusion, the author expresses the opinion that the deep-seated, ultra-basic zone, in which garnet and ferro-magnesian silicates predominate, was the medium in which the crystallization of the diamond occurred.—*Eng. and Min. Jour.*

FIRE TESTS OF WINDOW GLASS.

Windows and skylights of this material were recently tested at the plant of the British Fire-Prevention Committee. In the window test five squares of wire glass, 3 ft. 3 in. by 4 ft. 6 in., were set in a brick wall, one in a brick frame, two in steel frames and three in brick reveals. The glass was ¼ in. thick. The following details are from *Engineering News*, October 5, 1905 The first lasted for forty-five minutes, with temperatures ranging from 650 deg. F. to 1,540 deg. F.; immediately on lighting the gas the glass in all the openings cracked, particularly around the edges, but beyond the cracks increasing no particular change occurred during the firing. The fire did not pass through the glass. On application of water through a ¾-in. nozzle under forty-five pounds per square inch pressure, an irregular patch of small holes was made in the upper portion of the center window, which was also bulged inward; otherwise the glass in all the windows remained in position.

In the skylight tests four squares of glass, about 2 by 2 ft., were placed in the roof of the test house so as to be set horizontally. The fire lasted forty-five minutes and reached a temperature of 1,650 deg. F. Immediately on lighting the gas the glass in all four squares cracked in various directions; beyond this no perceptible change occurred during the fire test. Water was applied to the underside of the glass through hose and also poured on the tops of the glass; its effect was to develop hair cracks all over the glass, but no water passed through.—*Iron Age.*

ELECTRICAL SECTION.

(Stated Meeting, held Thursday, December 21, 1905.)

Electrochemical Calculations.

By Joseph W. Richards.

Electrochemical processes produce chemical changes through the agency of the electric current, and the current is used primarily either for its electrolytic effect or for its thermal effect. The first thing needful, in order to make any calculations connecting electric energy with thermal or chemical effect, is to set forth the values of electric energy as expressed in thermal or mechanical units, in order to get a common energy basis on which to make comparisons, and to postulate the facts concerning the electrolytic effect of the electric current.

ENERGETICS OF THE ELECTRIC CURRENT.

One watt-second of electric energy may be postulated as equivalent to one joule of mechanical work, or 0.2385 gram-calories. This is the energy basis on which electric and chemical phenomena meet on common ground, for the only energy measure of chemical reaction which has as yet been quantitatively investigated is the thermal one. We therefore express the energy of a chemical reaction in the terms in which that energy has been measured, and then have the theoretical basis for calculating the amount of electrical current which can theoretically furnish that amount of thermal energy.

PRINCIPLES OF THERMO-CHEMISTRY.

The measuring of the amount of heat liberated or absorbed in chemical combination or decomposition or reaction is the

province of thermo-chemistry. Many enthusiastic scientists have accumulated large numbers of these experimental data, from which, however, very few generalizations have been, up to the present, deduced. There are critical discussions of thermo-chemical data for inorganic compounds in Ostwald's "Allgemeine Chemie;" one can find the most complete collection of thermo-chemical figures yet published, both for inorganic and organic compounds, in Berthelot's "Thermochemie;" in English, Muir's "Elements of Thermal Chemistry" is the only collection of tables on this subject which aims at completeness, and the work is at present nearly two decades old. More or less incomplete or fragmentary tables can be found in works on chemistry or treatises on heat. In giving the data, chemists always give the heat change for molecular weights of the substances concerned; for instance

$$(H^2,O)=69{,}000 \text{ Calories}$$

means that when two parts of hydrogen unite with 16 parts of oxygen to form 18 parts of water, 69,000 heat units are evolved. If the weights of the substances be called kilograms, the heat units are kilogram-calories; if called grams, they are gram-calories; if called ounces or pounds, they are ounce- or pound-calories (1^0C). The Germans write the above (H^2,O = 690 K, in which K stands for 100 ordinary heat units; while the French write it (H^2,O) = 69.0 Cal., in which the weights of the substances are supposed to be taken in *grams*, and the heat evolved expressed in *kilogram*-calories. In our opinion, the English style first given, is logically and practically superior to the other two, and is the best to follow.

It must be borne in mind that almost without exception, the thermo-chemical data given in the tables are those which have been determined starting with the constituents at laboratory temperature and ending with the products at the same, or very nearly the same, temperature. The heat quantities therefore apply strictly only to electrochemical processes taking place at ordinary temperature, or very near thereto, and with the constituents or products in the same physical state as was used in the calorimetric determination. If the electro-chemical process is taking place at any different temperature, let us call it t°C.,and the ordinary temperature 15°C, the heat of the chemi-

cal change at t°, from constituentts at t° to products at t°, or *vice versa*, can be calculated from the rather simple rule, that—

The heat of combination at t° equals the heat of combination at 15° (tabulated heat), plus the heat necessary to raise the constituents from their ordinary state at 15° to their ordinary state at t°, and minus the heat which would be necessary to raise the products from their ordinary state at 15° to their ordinary state at t°.

The above calculation requires a knowledge of the specific heats and latent heats of change of state of the constituents and of the products of the reaction, between 15° and t°, but when these are known, the heat of the reaction at t°, the quantities very often needed in electro-chemical calculations, can be evaluated. These specific heats and latent heats are best obtained from such standard works as Landoldt and Bornstein's "Physikalische-chemische Tabellen," or works of similar scope in English.

FARADAY'S LAWS.

There is another and an entirely different quantitative relation between the amount of electric current used and the quantity of electrochemical action produced, which applies to direct current producing electrolysis. In this case, while the energy relations hold, yet they are conditioned by the fact that every coulomb of electricity passing produces a definite amount of chemical change, equivalent to the setting free of a certain weight of hydrogen, for instance, and the energy required must adjust itself to the bringing about of this amount of chemical change. I am referring, of course, to Faraday's discoveries, which may be briefly summed up in the two statements that

1. The amount of chemical change produced electrolytically by the current is proportional only to the amount of electricity passing, as measured in coulombs, and is independent of the strength or temperature of the electrolyte, or the size or distance apart of the electrodes.
2. The amount of different elements dissolved or set free by the passage of a given amount of electricity proportional to their chemical equivalents.

When it was determined experimentally that 0.00001035 grams of hydrogen is set free by one coulomb, or that 96,540 coulombs set free one chemical equivalent, one gram, of hydrogen, the whole scale of relations for all elements whose chemi-

cal equivalents were known, became known. The "*Faraday*," —96,540 coulombs, sets free, or tends to set free, in passing from an anode to a cathode, a chemical equivalent weight in grams of any element. No law of nature has been subjected to more rigorous tests than this law of Faraday, and it appears so far as a law without an exception.

EVOLUTION OF GAS ELECTROLYTICALLY.

A Faraday of current, 96,540 coulombs (representing 26.82 ampere hours) sets free 1 gram equivalent of metal or acid element or radical. If the element or acid radical is gaseous, there is a simple relation between the current flow and the volume of gas evolved, based on the observation that a gram equivalent of a monatomic gaseous element has a volume under standard conditions of temperature and pressure of 22.22 litres, of a diatomic gaseous element, of 11.11 litres, etc. Thus, 96,540 coulombs set free a gram equivalent weight of hydrogen, chlorine, sodium, zinc, etc. The formulæ for these in the gaseous state are Na, Zn, H^2, Cl^2; the molecules of these gases, representing 22.22 litres, contains therefore:

Na	molecule	—1	gram-equivalents	
Zn	"	—2	"	"
H^2	"	—2	"	"
Cl^2	"	—2	"	"
O^2	"	—4	"	"

Therefore, 1 Faraday (26.82 ampere hours) sets free 1 gram molecule of sodium vapor (22.22 litres), and ½ a gram molecule (11.11 litres) of vapor of zinc, hydrogen gas or chlorine gas, assumed at normal temperature and pressure. For any other temperature, t, or pressure, p, in m.m. of mercury, the volume would be—

$$\text{Standard Volume} \times \frac{273 + t}{273} \times \frac{760}{p}$$

Example: How much oxygen and hydrogen should be produced per day by 300 amperes passing through 20 cells in series?

Solution: The ampere hours performing electrolysis are

$$300 \times 20 \times 24 = 144{,}000$$

The Faradays' passing are

$$144{,}000 \div 26.82 = 5{,}370$$

The volumes of gas produced will therefore be

$$5{,}370 \times 11.11 = 59{,}670 \text{ litres of hydrogen.}$$
$$5{,}370 \times 5.55 = 29{,}835 \text{ litres of oxygen.}$$

If the gas evolved is a compound gas or acid radical, which is formed at the electrodes, the valence of the acid of basic constituent in a molecule of the gas, is the basis of calculation. For instance, CO,CO^2,CH^4,H^2S all represent molecules of the said gases, of a volume of 22.22 litres, and contain respectively—

CO contains	4	gram-equivalents	of	oxygen		
CO^2 "	4	"	"	"	"	
CH^4 "	4	"	"	"	"	hydrogen.
H^2S "	2	"	"	"	"	"

One Faraday (26.82 ampere hours) which would produce one gram-equivalent of oxygen or hydrogen, would therefore produce $\frac{1}{2}$ a molecule (11.11 litres) of CO or H^2S or $\frac{1}{4}$ molecule of CO^2 or CH^4 (5.55 litres).

Another means of calculating the volume of these gases is to note that CO^2 and H^2S are equal in volume to the oxygen or hydrogen contained in them, CO is double the volume of the oxygen contained in it, and CH^4 is double the volume of the hydrogen going into its composition; so that the volumes of the compound gases can be calculated from the volumes of the simple gases going into their formation. The relations alluded to are shown by the Roman numerals indicating molecules or volumes in the following equations:

$$\overset{\text{I}}{O^2} + 2C = \overset{\text{II}}{2CO}$$

$$\overset{\text{I}}{O^2} + C = \overset{\text{I}}{CO^2}$$

$$\overset{\text{II}}{2H^2} + C = \overset{\text{I}}{CH^4}$$

$$\overset{\text{I}}{H^2} + S = \overset{\text{I}}{H^2S}$$

OHM'S LAWS.

The resistance which the electric current encounters to its flow through the body of a substance is determined by the specific resistivity of the body per unit cube of substance, multiplied by its length and divided by its cross-sectional area. The specific resistivity is given in tables per centimeter cubed, in ohms, and the simple arithmetic described gives us the resistance of any bar or wire of said material. The resistance of the body being known, Ohm's laws furnish us with the relation between the applied voltage and current flow through the body, as follows:

$$\text{Current} = \frac{\text{potential drop}}{\text{resistance}}$$

or

$$\text{Amperes} = \frac{\text{volts drop}}{\text{ohms resistance}}$$

These relations apply to the current *in the body* of an electrolyte just as strictly as to a metallic wire (and tables of specific resistivity of electrolytes are given in almost all books on electrochemistry),* but they do not apply at all to the resistance or drop of potential at the surface of an electrode, that is, at the contact surface where current enters or leaves an electrolyte. That latter potential drop is due to chemical work being performed, and has no connection whatever with ordinary ohmic resistance and Ohm's laws.

RESISTANCE CAPACITY OF VESSELS.

In making electrochemical experiments, as in tubes or in vessels between fixed electrodes, it is often convenient to calculate, as a constant of the apparatus, the "resistance capacity" of the vessel. This is simply its ohmic resistance, between the two fixed electrodes, supposing it to be filled with a liquid whose specific resistance is unity. If the cross section is uniform, and the electrodes of similar area, this resistance capacity

*Kohlrausch and Holborn's "Leitungsfähigkeit der Elektrolyte" is the most complete collection of such data.

would be, in ohms, supposing the measurements made in centimeters:

$$\text{resistance capacity} = \frac{\text{length between electrodes}}{\text{cross-sectional area of electrolyte}}$$

Thenceforth, if said vessel is filled between the electrodes with a liquid whose specific resistance is known, the ohmic resistance of the electrolyte will be simply the product of the resistance capacity by the specific resistance of the given liquid used: that is Ohmic resistance of electrolyte = resistance capacity of the vessel × specific resistance of electrolyte.

DETERMINATION OF OHMIC RESISTANCE.

If the conductor is not electrolysed by the current, its resistance is measured by sending a known current through it and measuring the drop of potential at its terminals.

$$\text{resistance (in ohms)} = \frac{\text{potential drop (in volts)}}{\text{current flowing (in amperes)}}.$$

The current used may be either direct or alternating, the former is preferable because of the more accurate measurements possible. Another method, not so often used, but applicable under many circumstances, is to put a delicate thermometer or thermo-couple in contact with the conductor and measure the rate at which its temperature *begins* to rise. Knowing its specific gravity (weight of one cubic centimeter in grams) and its specific heat (per unit of weight), the heat generated per second in one cubic centimeter is known:

Heat generated (gram calories) = specific gravity × specific heat × rise of temperature per second.

But, this quantity is also equal to the heat value of the current used, which is 0.2385 times the watts used, or 0.2385 times the square of the current used into the resistance. We therefore have—

$$\text{resistance (in ohms)} = \frac{\text{heat found calorimetrically}}{0.2385 \times (\text{current used})^2}$$

The above method is particularly applicable to electrolytes

of any kind if they are placed in a long tube of low heat-conducting material, and the rise of temperature thus measured at a point remote from the electrodes. Then, whatever action, chemical or thermal, occur at the electrodes, and whatever potential drop may occur, it is only necessary that the amount of current passing be accurately measured, the specific heat and specific gravity of the electrolyte be known, and the rate of rise of temperature be measured at the first few seconds after turning on the current, to be able to calculate the specific resistance.

The use of alternating current for measurements of ohmic resistance using Kohlrausch's method of Wheatstone bridge and a telephone is applicable with accuracy to non-electrolytic conductors, and has benerally been assumed to be applicable quite as accurately to electrolytes. Recent work on the possibility of electrolysis occurring when alternating current is passed through an electrolyte has rather cast doubts upon the accuracy of these tests. It is possible that most determinations thus made have been free from error, but we can understand now that tests so made might be erroneous in many instances, if made with certain electrodes and with certain frequency of alternation of the measuring current.

For many practical purposes, the ohmic resistance of an electrolytic cell can be determined by the following simple device and calculation: Use electrodes equal to the cross section of the electrolyte, and put in series with a relatively high resistance, so as to keep the strength of current as nearly constant as possible. Measure amperes and voltage drop with the plates as wide apart as possible; draw together till they are exactly half the distance apart, and measure again. If the outside resistance is high enough, the amperes will be constant within the ability of the ammeter to record, while the voltage will decrease. Double the decrease in voltage will be the total voltage drop in overcoming the ohmic resistance of the whole cell. Designating this as the voltage drop due to electrical conductivity of the electrolyte, V^c, we have:

$$\text{Resistance of cell (in ohms)} = \frac{V^c}{\text{amperes passing}}$$

VOLTAGE DROP AT THE ELECTRODE SURFACES.

This is the loss of potential across the electrodes corresponding to the work done at the electrodes. It is practically determinable by measuring the total potential drop, and subtracting from it the drop due to overcoming the ohmic resistance of the electrolyte. Calling V the total drop of potential, and V^d that part of it absorbed in chemical (or physical) work at the surface of the electrodes, then

$$V^d = V - V^c.$$

If V^c has been determined in the manner described in the last paragraph, or has been calculated from the specific resistance of the electrolyte, properly determined, and the resistance capacity of the electrolytic vessel, then V^d represents accurately the voltage drop due to all phenomena occurring *at the surface* of the electrodes, as distinguished from the mere phenomenon of electric conduction, ruled absolutely by Ohm's law, occurring *in the body* of the electrolyte.

It may not be amiss to remark, *en passant*, that the fact that Ohm's law applies absolutely to the conduction of electricity through the body of an electrolyte, in the same manner as in a metallic conductor, combined with Prof. Hopkins' recent determinations that the conducting of the current is practically instantaneous in electrolytes, as it is in solids, and that the body of an electrolytic conductor acts in all respects magnetically, etc., exactly the same as the body of a metallic conductor—all prove the identity of the mechanism of electric conduction through the substance or body of an electrolytic conductor and through solid metallic conductors. The phenomena at the bounding surfaces, the electrodes, are different in the two cases, but there is no experimental evidence of any dissimilarity in the mechanism of the conduction in the body of the conductors in the two cases.

TRANSFER RESISTANCE.

This is supposed to represent resistance to the passage of the current from the electrolyte to the electrode, of the nature of the work done when current is passed across a thermo-electric junction; that is, it is a resistance purely phys-

ical in its nature, existing simply because the current passes from one conducting substance to another one, and, finally, a resistance which causes the current to either generate heat, by heating this junction, or to absorb heat, by cooling the junction. It is therefore a reversible phenomenon, either subtracting potential from the current in such quantity as that the heat thus generated represents the heat equivalent of the watts thus lost, or else contributing potential to the circuit in such quantity that the potential thus furnished represents, when multiplied by the amperes flowing, the watt equivalent of the heat energy absorbed.

In your lecturer's opinion, this transfer resistance must be very small. Since it would be of different signs at the two electrodes, absorbing voltage at one and generating nearly an equal amount at the other, the difference between two quantities in themselves small, must be of a low order of magnitude. Further, no reliable determinations are at hand concerning these + and — thermo-electrical potentials, because of the inevitable complication of the measurements by purely chemical changes. For instance, one investigator kept two zinc electrodes in zinc-chloride solution, but at 20° C. difference of temperature, and measured the difference of voltage, calling it thermo-electric difference of potential; but aside from the fact that this ignores any thermo-electric difference of potential between the hot and the cold solutions or in any part of the external circuit, it is certain that it ignores the difference between the heat of formation of zinc chloride in aqueous solution at two temperatures 20° apart, which might easily be equal to the whole potential difference noted. Until, therefore, physicists have cleared up satisfactorily this whole subject of thermo-electric potential between electrodes and solutions, we are making a less error in leaving out its consideration than in trying to account and allow for it—particularly since we know that some of the so-called allowances are certainly erroneous.

I have left out of the definition of transfer resistance that produced by a change in the electrode whereby a film of insoluble salt or gas is produced and so chokes off the current. Such action is polarization, and such change in the original conditions, practically introducing modified or even new electrode surfaces, is not transfer resistance, properly speaking.

VOLTAGE REQUIRED FOR CHEMICAL WORK.

We arrive here at the kernel of electrolytic calculation, the sole and sufficient basis being that the amount of electrical energy expended in doing chemical work must equal the energy equivalent of the chemical work done. If that position does not hold in this question, then energy could be created or lost, and the principle of the conservation of energy violated. We must admit, however, that if an electrolytic cell cools off while the current is passing, that external heat energy is being supplied which will diminish, by the amount so supplied, the work being done by the current. However, that quantity is in the nature of a possible correction, while the heat of the chemical reaction produced is the principal factor.

We must remark at the outset that the chemical work done means the whole change from the system before electrolysis to the system after electrolysis. There is no division of the chemical work of the current into that required for assumed primary reactions and that for assumed secondary reactions. Only changes taking place at the surface of the electrodes, however, affect the energy requirements; chemical reactions taking place away from immediate contact with the surface of the electrodes neither absorb energy from the circuit nor deliver energy to it,—they are purely incidental and independent chemical phenomena.

Knowing that 96,540 coulombs set free one chemical equivalent weight in grams of an element, or decompose one chemically equivalent weight in grams of a substance, or, in more general terms, reduce by one valency atomic weight of any chemically basic element, or increase by one valency atomic or molecular weight of any chemically acid element or radical,—we can soon foot up the chemical energy of the change produced. The thermochemical heat absorbed in the separation of a chemical equivalent weight of an element is the energy required to isolate it; and since the passage of 96,540 coulombs produce that change, the voltage drop must be such that the calculated heat equivalent of the electric energy expended—

$$96{,}540 \times \text{voltage drop} \times 0.2385$$

is equal to the thermochemical heat absorbed (Q for 1 equiva-

lent). The voltage drop for the decomposition (V^d) must therefore be—

$$\text{Voltage drop} = \frac{\text{Q for 1 equivalent}}{23{,}040}$$

These calculations have been made and verified by experiment on many chemical compounds. There are some few exceptions, but many such have subsequently been shown to be only apparent exceptions, the real reaction occurring during electrolysis not having been exactly understood, or else the thermochemical data not applying strictly to the conditions under which electrolysis took place.

(*To be concluded.*)

Book Notices.

Eléments de Chimie Inorganique. Prof. Dr. W. Ostwald. Traduit de l'allemande par L. Lazard. II Partie. Metaux. Paris: Gauthiers-Villars, 1905. (Price, fcs. 15.)

This work constitutes a large 8-vo. of some 450 pages giving to French readers a satisfactory translation of the inorganic portions of Ostwald's standard treatise on the Elements of Chemistry. W.

The Insulation of Electric Machines. By Harry Winthrop Turner and Henry Metcalf Hobart, with 162 illustrations. Large 8-vo., pp. xvi 297. Whittaker & Co., London. 1905. (10s. 6d. net.)

The effective insulation of electric machines has been one of the most difficult technical problems with which the electrical specialist in this field has had to contend, and much still remains to be done. The present work gives in satisfactory form a summary of the present state of the art, and may be consulted profitably by those directly interested in the subject.

W.

Cement and Concrete. By Louis Carlton Sabin, B. S., C. E., Assistant Engineer, Engineering Department U. S. Army, &c. Large 8-vo., pp. x + 507. New York: McGraw Publishing Co. 1905. (Price, $5.00.)

The use of cement in construction has of late made such important progress that a new treatise on the subject, giving the results of the application of the material in its most advanced phases, from the hands of an expert, will be received with singular interest; more especially since the advance in this branch of the constructive arts has been so rapid of late as to have outstripped the literature in book form, and inquirers have been compelled to seek their information in the scattered pages of the publications of the various engineering societies. To such the present volume will prove very helpful. W.

Elektrolytische Verzinkung von Sherard Cowper-Coles, London. Ins Deutsche Uebertragen von Dr. Emil Abel. Chemiker der Siemens & Halske A. G., Wien. Mit 36 Figuren and 9 Tabellen im Text. Halle a. S. Verlåg von Wilhelm Knapp, 1905. (Price, 2 marks.)

Dié elektrolytische Chloratindustrie. Von John B. C. Kershaw, F. I. C. London. Ins Deutsche Uebertragen von Dr. Max Hutte, Chemiker der Siemens & Halske A. G., Berlin. Mit 39 Figuren and 3 Tabellen in Text and einem Anhang welche die Wörtliche Wiedergabe der wichtigsten Patente enthält. Halle, a. S. Verlag von Wilhelm Knapp, 1905. (Price, 6 marks.)

The two works above named constitute volumes xviii and xix of the highly-useful Electrochemical Monographs that have been appearing during the past few years from the Knapp press.

The first discusses the subject of zincing by electrolytic methods, which, within a recent period have been so substantially developed that they have been able to compete in the commercial way with the old process of galvanizing by dipping. The second treats of the electrolytic methods for the production of chlorates, perchlorates, bromates and iodates, which have achieved considerable commercial success. A useful compendium of the patent literature of various countries bearing on the subject is presented in an appendix. W.

Alternating Current Engineering practically treated. By E. B. Raymond, Testing Department General Electric Co., with 112 illustrations. 8-vo. pp. vii + 225. New York: Van Nostrand Co., London. Kegan Paul, Trench, Trübner & Co. 1904. (Price, $2.50 net.)

This subject is treated in two parts; the first treating of the general laws of magnetism and alternating currents; and the second, to modern alternating current apparatus, methods of operation and testing. The work is intended specially for the use of those who are inexperienced in the management of this class of electrical machinery, and should be found very useful. W.

Le Abitazioni Popolari (Case operaie), dell' Ing. Effren Magrini. Con 151 incisioni. Milano: Ulrico Hoepli. 1905. 12mo. pp. xvi × 309.

This work treats in a concise and masterly way the subject of the habitations of workingmen. Part first treats of the legislation of various countries on the subject, and the character and influence of various local institutions, such as building and other public and private coöperative societies. The second part treats specially of the plans and methods of a number of the great industrial establishments, such as Krupp's, in Germany; Schneider & Creusot, in France; the Gemeinnützige Bau-Gesllschaft, in Manheim; the Willemantic Linen Co., in this country, and numerous other corporations for the housing of their operatives. The illustrations are numerous and instructive. W.

The Proceedings of the Society for the Promotion of Engineering Education. Twelfth annual meeting, held in St. Louis, Mo., September 1-3, 1904. Edited by C. Frank Allen, Fred. W. McNair, Milo S. Ketchum, Committee. New York: Engineering News Publishing Co. 1905.

Recent Advances in the Metallurgy of Iron and Steel. R. S. Hutton. Reprint from the Journal of the Society of Chemical Industry, 15 June, 1905.

Notes on Heat Insulation, particularly with regard to materials used in furnace construction. R. S. Hutton and T. R. Beard. Reprint from the transactions of the Foundry Society, August, 1905.

Correspondence.

HIGH-GRADE SILICON FOR PURIFYING CAST-IRON.

To the Editor:—Since the publication of my paper on "Recent Progress in Metallurgy," in the December issue of the *Journal* of the Franklin Institute, I have received the enclosed interesting letter from Dr. Moldenke, which he has kindly authorized me to send to you as a contribution to the discussion of the subject.

As Dr. Moldenke is a metallurgical chemist of international reputation, who has had wide experience, especially in cast-iron industries, his views are valuable and it is especially gratifying to find that he states that the process alluded to is "entirely new."

His theory regarding the seeming paradox of obtaining "increase in strength, where the reverse would be expected when softening," agrees exactly with my own views, as will appear from the following quotation taken from the *Journal* of the Franklin Institute, March, 1888, in which I announced the result of experiments made in adding ferro manganese to car-wheel iron:

"A remarkable effect is produced upon the character of hard iron by adding to the molten metal, a moment before pouring it into a mould, a very small quantity of ferro-manganese, say one pound of ferro-manganese in 600 pounds of iron, and thoroughly diffusing it through the molten mass by stirring with an iron rod. The result of several hundred carefully-conducted experiments which I have made, enables me to say that the transverse strength of the metal is increased from thirty to forty per cent., the shrinkage is decreased from twenty to thirty per cent. and the depth of the chill is decreased about twenty-five per cent., while nearly one-half of the combined carbon is changed into free carbon; the percentage of manganese in the iron is not sensibly increased by this dose, the small proportion of manganese which was added being found in the form of oxide in the scoria. The philosophical explanation of this extraordinary effect is, in my opinion, to be found in the fact that the ferro-manganese acts simply as a deoxidizing agent, the manganese seizing any oxygen which has combined with the iron, forming manganic-oxide, which being lighter than the molten metal, rises to the surface and floats off with the scoria. When a casting which has been artificially softened by this novel treatment is re-

melted, the effect of the ferro-manganese disappears and hard iron results as a consequence."

The high-grade ferro-silicon (50 per cent. silicon) acts in a similar manner not only increasing strength but softening the metal.

Small pulleys cast from iron treated in the way I described are now being turned at 40 feet per minute, whereas the usual speed of turning the same class of pulleys from the same grade of soft iron untreated is 25 feet per minute.

I stated in my paper that as a result of a large number of tests I had found an average increase in strength of about 15 per cent. accompanied by marked increase in softness. I now have records showing much larger gain in strength and resistance (over 25 per cent.) accompanied by remarkable increase in softness. These tests were cast from iron containing 15 per cent. of steel in the mixture.

Very truly,

A. E. OUTERBRIDGE, JR.

PHILADELPHIA, PA., Dec. 23d, 1905.

AMERICAN FOUNDRYMEN'S ASSOCIATION,

Secretary-Treasurer Richard Moldenke.
Natchung, N. J.

President, Thos. D. West.
Thos. D. West Foundry Co., Sharpsville, Pa.

Office of the Secretary,
WATCHUNG, N. J., Dec. 17th, 1905.

MY DEAR MR. OUTERBRIDGE:—

Thank you very much for your valued article. I have read it with great interest. The portion anent the addition of high-grade silicon is especially valuable and entirely new. You will no doubt find that the increase in strength, where the reverse would be expected when softening, is due to the purifying effect of the silicon addition when not made in the cupola. This is similar to that produced by ferro-manganese when added to the car-wheel mixtures. I hold that these alloys when they are effective at all, do take out dissolved oxygen or perhaps other gases, bringing out silicon or manganese as the case may be, and passing into the slag. The result is a cleaning up and better adherence of the crystals, raising the resilience and general strength.

I think you will find further that where steel additions have been made, you will get still better results, as the melting point being raised, these alloys get in their work better.

Your paper shows that we have not yet exhausted our resources in the foundry. May you discover many new ways and means yet.

Sincerely yours,

(Signed) RICHARD MOLDENKE.

Sections

SECTION OF PHYSICS AND CHEMISTRY. *Stated Meeting*, held Thursday, December 7, 8 P.M. Dr. Edward Goldsmith in the chair. Present, thirty-seven members and visitors.

The communication of the evening was presented by Dr. Henry Leffmann. The speaker exhibited and discussed a number of new laboratory appliances and analytical methods. Dr. W. J. Williams and the speaker discussed the subject. The chairman expressed the thanks of the meeting to the speaker. Adjourned.

WM. H. WAHL, *Sec'y pro tem.*

SECTION OF PHOTOGRAPHY AND MICROSCOPY. Thirty-fifth Stated Meeting, held Thursday, December 14th, 8 P.M. Dr. Henry Leffmann in the chair. Present, seventeen members and visitors.

Mr. J. W. Ridpath exhibited and described an inexpensive dark-room lantern. He said in substance, "About five years ago I made for my own use an inexpensive dark-room lantern, by which the unpleasant effects of heat and smell were avoided.

"The first lantern, which is still in use, was experimental, and made from a cigar box 3½x5½x6½ inches.

"The lid was removed and the orange-colored paper lining left in place. A small hole was bored in one end, intended for the bottom, to allow the expanding air to escape. A larger hole was bored in the other end, intended for the top; into which was fitted a receptacle for an Edison incandescent electric light; this was held in place by a few drops of glue. Into this receptacle was screwed a low c. p. incandescent lamp of the proper voltage. A sheet of orange-colored glass, the same size as the original lid, was put in place where the lid formerly belonged. This glass was secured in place by binding strips. A sheet of ruby glass as long and wide as the outside dimensions of the box was then placed over the orange glass and secured in place by binding strips. A suitable plug to screw into an Edison receptacle was placed on the outer end of the cord, and the lamp was ready for use.

"For developing plates particularly sensitive to colored light, a few curtains made of cherry-colored tissue paper were hung in front of the glass, being pasted to the top of the box. After development has proceeded sufficiently for safety, one or more of these paper curtains can be raised and placed on the top of the lantern. This lantern is quite convenient, cool and comfortable to work by, especially in warm weather."

Mr. Hugo Bilgram referred to an interesting specimen of quartz which exhibited the so-called Brownian movements, and exhibited a specimen of the same mounted as a microscopic slide, which the members were given the opportunity of examining. Dr. Edward Goldsmith made some comments on the frequency with which such and similar enclosures are found in quartz.

Dr. Leffmann showed with the lantern a picture of the mosquito, which is believed to be the direct source of yellow fever infection and another showing the parasite which is the cause of the characteristic anemia so commonly found in semi-tropical countries. Adjourned.

M. I. WILBERT, *Sec'y.*

ELECTRICAL SECTION. *Stated Meeting*, held Thursday, December 21, 8 P.M. Mr. Thomas Spencer in the chair.

Present, forty members and visitors.

The paper of the evening was read by Prof. Joseph W. Richards, of Lehigh University, on "Electro-Chemical Calculations."

The subject was discussed by Prof. Carl Hering, Mr. C. J. Reed, Mr. A. Simonini, Mr. Thomas Spencer, Mr. S. S. Sadtler, Dr. E. Goldsmith and the speaker.

The thanks of the meeting were voted to the speaker of the evening and the session was adjourned.

WM. H. WAHL, *Sec'y pro tem*

MECHANICAL AND ENGINEERING SECTION.—*Stated Meeting*, held Thursday, January 11th, 8 P.M. Present, twenty members and visitors.

President Charles Day in the chair.

The annual election was then held, and resulted in the choice of the following officers to serve for the year 1906:

President, Mr. Chas. Day.

Vice-Presidents, Mr. Kern Dodge, Prof. H. W. Spangler.

Secretary, Mr. Francis Head.

Conservator, Dr. Wm. H. Wahl.

The paper of the evening was read by Prof. Wm. H. Marks, of Philadelphia, on "The Finances of Engineering Enterprises," which was discussed by Mr. James Christie, Dr. Edward Goldsmith, the President of the Section, and the speaker.

Adjourned.

FRANCIS HEAD.

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—Thirty-sixth Stated Meeting, held Thursday, January 18th, 8 o'clock P.M. Present, sixty-five members and visitors. Dr. Henry Leffmann in the chair.

The annual election of officers resulted in the choice of the following, to serve for the year 1906, viz.:

President, Dr. Henry Leffmann.

Vice-Presidents, Mr. J. W. Ridpath, Mr. U. C. Wanner.

Secretary, Mr. Martin I. Wilbert.

Conservator, Dr. Wm. H. Wahl.

The communication of the evening was presented by Mr. U. C. Wanner on Floral Photography, and the coloring of lantern slides.

Mr. Wanner gave an interesting description of his method of procedure, and proceeded thereupon to exhibit a considerable collection of colored lantern photographs of floral subjects, which in respect both of photographic technique and exquisite coloring, represented the highest order of excellence. The communication was freely discussed by a number of members and the author.

Dr. Leffmann exhibited an interesting lantern photograph, showing the ancient Indian Reservation near Second and Walnut streets, set apart in Colonial times for use in occasional conferences between the authorities of the Province of Pennsylvania and the neighboring Indian tribes.

Some additional slides were shown, after which the meeting was declared adjourned.

M. I. WILBERT, *Secretary.*

Franklin Institute.

Proceedings of the annual meeting held Wednesday, January 17, 1906.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 17, 1906.

PRESIDENT JOHN BIRKINBINE in the chair.

Present, 123 members and visitors.

Additions to membership since last report, 9.

The annual reports of the Board of Managers with appendices embracing the annual reports of the several committees of the Institute and the Board, and of the Trustees of the Elliott Cresson Medal Fund were presented and accepted.

President Birkinbine made an address referring to the present occasion of the 200th anniversary of the birth of Dr. Benjamin Franklin and outlined briefly the plans contemplated by the Institute for celebrating the anniversary. (The address appears as an appendix to these minutes.)

The Secretary presented and read a communication received from The American Philosophical Society, inviting the Institute to be represented at the Franklin Bi-Centennial Anniversary to be held by the Society, April 17th to 20th, 1906. The communication was referred to the Board of Managers.

The President then introduced Prof. Albert H. Smyth, Professor of English Literature in the Central High School of Philadelphia, who gave a most eloquent and interesting address on "Franklin as a Man of Letters."

The meeting passed a vote of thanks to the speaker, with the request that he prepare his remarks for publication in the Franklin Memorial issue of the *Journal,* which it is contemplated to publish in due course.

Mr. W. N. Jennings followed with an exhibition of lantern photographs relating to Franklin and his works.

The tellers of the annual election reported the election of all the candidates nominated at the stated meeting of Wednesday, December 20, 1905.

who were thereupon declared elected to the offices for which they were respectively named. The tellers were given a vote of thanks.

Adjourned.

WM. H. WAHL, *Secretary.*

ADDRESS OF PRESIDENT BIRKINBINE.

Two hundred years ago Benjamin Franklin was born in Boston, but as so much of his time was spent in Philadelphia, where he developed most of his admirable qualities, and where he attained prominence as a printer, philosopher, author and statesman, it is appropriate that the anniversary of his birth be celebrated in Philadelphia, and that this celebration should start at the Franklin Institute.

The Board of Managers have decided to recognize this anniversary by a series of commemorative addresses and papers, the first of which you will listen to to-night. "Franklin as a Man of Letters" will be presented to you, and at the next monthly meeting "Franklin as a Man of Science" will be discussed.

The Board of Managers had also taken the initiative steps for an industrial exposition the coming Fall, the only drawback to assuring this enterprise being the uncertainty of obtaining accommodations for the exhibits. Tentative arrangements had been made for the use of the main exhibition hall and one of the permanent pavilions, and also the outside ground connected with the Commercial Museum in West Philadelphia. These plans may be interfered with by the avowed intention of the City authorities to use the pavilion as a temporary addition to the Almshouse. Hence, definite announcement of the Exhibition cannot be made at the present time.

In April the American Philosophical Society of this city, which joins the University of Pennsylvania in crediting Franklin as its founder in 1743, will give expression of its appreciation of Franklin's worth by an assemblage of international scientists of world-wide reputation, an occasion which all Philadelphians may look forward to with satisfaction.

It is not my function to discuss Franklin and his achievements, but I think that we can appreciate what he has accomplished better if we picture to ourselves the conditions in and about Philadelphia in the time of Franklin.

Can you see a runaway apprentice, not yet eighteen years of age, completing a journey of three hundred miles, part of it on foot, and part of which he literally worked his passage by rowing a boat, arriving in Philadelphia wearied and hungry, with a dollar of available funds in his pockets? And can you see the same man twenty-five years later, practically retired from business with a competence sufficient to sustain him, and with fame which spread far and wide, a truly self-made man?

The neighborhood of the Institute home is replete with reminiscences of Franklin. Dying at the age of eighty-four years, his remains are interred within four blocks of this hall, and somewhere in the open fields, betweeen where you sit and the present post office site, it is claimed he made his famous experiment of conducting lightning from the clouds, in 1752. Most

of his work was done within half a mile of this locality, for Philadelphia was then a moderate-sized town. Its navigation was confined entirely to sailing crafts and row boats, for there were no steamships; in fact no steam engines. Transportation was on horse-back, in carriages, or by stage coach. The wood pump and old oaken bucket were the source of water supply, and consequently there were no filtration scandals, and there was no excitement over gas works lease. There were no railroads, and none to sorrow over the withdrawal of passes. The abundance of clay, supplemented by liberal drafts of cobbles from the river, precluded any asphalt complications.

With wood for fuel, there was no demand for ordinances abating smoke nuisances, or fear of coal strikes. There were no department stores, unless we credit Franklin with initiating them by his modest enterprise in which it is reported he disposed of a variety of goods, from books to human chattels.

The absence of sky-scrapers eliminated one danger from elevator accidents, and Franklin could pursue his studies free from interruption from a telephone call, or from insurance or book agents.

To-night we see our City Hall outlined with thousands of lights to honor the memory of the man who first controlled electricity.

Hundreds of thousands of our town people have to-day ridden in cars propelled by electricity or steam.

Tens of thousands of horse power are hourly developed by coal mined far below the earth's surface.

Over fifteen hundred miles of streets cover water and gas pipe, sewers, light and telephone conduits, etc., probably sufficient to cover one-half the earth's circumference, and messages flash, or power is transmitted by overhead wires aggregating a greater distance.

Report of the Board of Managers for the Year 1905, with Appendices Embracing the Annual Reports of the Various Committees and Sections.

Presented and Accepted at the Annual Meeting of the Institute, held Wednesday, January 17th, 1906.

To the Members of the Franklin Institute:

In presenting this report your Board of Managers expresses the hope that the 200th Anniversary of the birth of Benjamin Franklin may be recognized in such manner as to materially advance the Institute which bears the name of this illustrious American.

Eighty years of sustained effort in advancing the Mechanic Arts has honored the name of Franklin, and won for the Franklin Institute world-wide fame, to which it is justly entitled. But this effort has failed to enlist

the financial support necessary to permit the self-imposed work being so prosecuted as to keep the Institute as well in advance as it should be.

Our unequalled Technical Library demands each year large expenditures to maintain it as a complete reference library, and the opportunities for scientific investigation need liberal expenditures.

The Committee on Exhibitions is seriously considering a celebration of the Bi-Centennial of Franklin's birth by an exhibition in Philadelphia, believing that the time is opportune. What more fitting recognition than an exhibition of the Graphic Arts and a display which would demonstrate the marvellous advance, since close to our Institute home, Franklin drew electricity from the clouds?

The reports of the various committees of the Board and of the Institute, and records of the schools, which are important features of the Institute's work, appended hereto, give details of what has been accomplished during the year, but the results may be summarized as follows:

For eight decades the Night Schools of the Franklin Institute have attracted men, who, in the endeavor to help themselves, received in these practical aid, and many who later achieved prominence, made their initial start in these schools. During the past year 601 students were in attendance in the night schools; 447 studied drawing; 96 machine design, and 28 naval architecture.

It would be interesting, were it possible, to trace the advance in education, and in science, due directly to the conscientious work of preceptors and scholars in the Franklin Institute schools. The gratuitous assistance given students by the Institute's Professors and Lecturers deserve cordial recognition.

The Committee on Science and Arts reports the recommendation of the award of 21 medals, 2 certificates of merit, and making five advisory reports, with 41 cases pending at the close of the year.

The work of this Committee has, as in the past, honored the Institute, and through it given public recognition to meritorious discoveries and inventions.

Our Library, with 59,089 volumes, and pamphlets, maps, drawings, etc., making an aggregate of 107,470 titles, is a feature of the Institute which must be preserved and maintained.

The Board regrets that the income limits the appropriation to the Library Committee and forces it to use, not only economy but parsimony, in increasing and caring for the unique collection of scientific works.

The Activity of the Sections drew to the 32 meetings many contributions which otherwise would be presented at the Institute meetings, but at the latter, subjects of general interest have been considered, and in addition two courses of popular, well-attended lectures were given in the Young Men's Christian Association Auditorium.

The subjects, and discussions thereon, have supplied ample material for the *Journal* of the Franklin Institute, which carries to all parts of the world the record of work accomplished.

The Roll of Members, now 1,554, is far below what it should be to properly

sustain the work above outlined, for much of the expense of this, as the financial statement indicates, is met by membership dues.

The Board has accepted grateful contributions of books and other documents, which have been added to the library. It also acknowledges donations which have somewhat augmented the available funds of the Institute. But the limited endowment, and the decreased interest obtainable, demand that every expenditure be reduced and seriously limits the good which the Institute could accomplish. The total invested funds of the Institute, including all special funds, amounts to $141,325.10, and the value of building site and contents will fully double this.

The Board wishes to express its thanks to the lecturers, most of whom have rendered gratuitous services, and to the various committees of the Institute and Board which have done so well with restricted facilities.

By order of the Board,

JOHN BIRKINBINE,
President.

FINANCIAL STATEMENT FOR 1905.

RECEIPTS.

Balance on hand January 1, 1905				$2,255 08
Committee on Publications			$2,074 74	
Committee on Library			13 64	
Committee on Instruction			1,952 25	
Committee on Science and Arts			119 39	
Curators (a reimbursement)			20	
Contributions of members	1904-5	$1,056 25		
" " "	1905-6	4,448 00		
" from Stock	1901-2	6 00		
" " "	1902-3	12 00		
" " "	1904-5	102 00		
" " "	1905-6	340 00		
" from non-res. mem.	1903-4	12 00		
" " "	1904-5	647 00		
" " "	1905-6	928 00		
Entrance fees non-resident members		140 00	7,691 25	
Fees from life memberships			425 00	
Interest Phila. & Reading Gen. Mtg. Bonds			200 00	
" C. R. R. of N. J. 5 per cent. Bonds			100 00	
Dividends on Penn'a R. R. Stock			66 00	
Income, Estate of Robert Wright			2,212 26	
Income from General Endowment Fund			2,162 52	
Income from Bloomfield Moore Fund			622 82	
Income from M. Carey Lea Fund			192 80	
Income from Jas. T. Morris Memorial Fund			180 00	
Donation of Mrs. Alice Gibson Brock			1,000 00	
Donation of Entertainment Committee Iron and Steel Institute (for library purposes)			942 50	

Certificates of Membership	10 00	
Membership Badges	22 00	
Scott Legacy Premiums	220 00	
Bills Payable	16,320 98	
Index to *Journal of Franklin Institute*	4 00	
Membership Directory	329 60	36,861 95
		$39,117 03

PAYMENTS.

Committee on Publications	$7,340 34	
Committee on Library	1,795 02	
Committee on Instruction	2,223 76	
Committee on Meetings	399 52	
Committee on Science and Arts	357 50	
Com. on Elections and Resignations of Members	735 50	
Curators	1,980 98	
Incidental Expenses	765 19	
Salaries and Wages	5,464 33	
Joint Section Account	520 31	
Insurance	466 31	
Income, Gen. End. Fund (an interest payment)	200 00	
Income Bloomfield Moore Fund	116 62	
Income M. Carey Lea Fund	13 80	
Publicity Fund	125 00	
Expenditures from Donation, Iron and Steel Inst. Committee	53 72	
Certificates of Membership	3 75	
Membership Badges	10 50	
Scott Legacy Premiums	320 00	
Bills Payable	14,000 00	
Bloomfield Moore Fund, Expenditures	176 23	
M. Carey Lea Fund, Expenditures	122 97	
Jas. T. Morris Mem. Ed., Expenditures	116 67	
Memo. Library Fund, Expenditures	76 86	
Interest on Temporary Loan	106 46	
Membership Directory	485 12	
Fees for Life-Memberships (turned over to Trustees)	425 00	38,463 33
Balance January 1st, 1906		$653 70

ENDOWMENT FUNDS.

(In the hands of the Institute.)

Bloomfield H. Moore Memorial Fund	$15,000 00	
Memorial Library Fund	1,000 00	
H. H. Bartol Fund	1,000 00	$17,000 00

(In the hands of Elliott-Cresson Trustees.)

The Elliott-Cresson Medal Fund		4,811 66

(In the hands of the Board of Trustees of the Franklin Institute.)

The Legacy of George S. Pepper	$38,937 50	
The Legacy of Eugene Nugent	1,000 00	
The Legacy of Emily B. Nicholson	1,520 00	
The Edward Longstreth Medal Fund	1,000 00	
The Jas. T. Morris Memorial Fund	4,000 00	
Donation of unknown friend	5 00	
Donation of a friend who desires his name withheld	5,000 00	
Life Membership Fund since October 1st, 1894	3,803 00	
Journal Endowment Fund	138 00	
Donation of E. G. Acheson	20 00	
Donation of E. M. Walsh	10 00	
Special Endowment Fund	11,940 00	
By the will of John Turner, deceased, one-fourth of net income on 2 per cent. of his residuary estate, yielding about $100 or more per year, equivalent to a principal of	2,000 00	
By the will of Robert Wright, deceased, the institute is now in receipt of the income of a principal sum of about	50,000 00	119,373 50
		$141,185 16

(An increase in 1905 of $569 15.)

REPORT OF THE LIBRARY COMMITTEE FOR THE YEAR 1905.

To the President and Members of the Franklin Institute:

The Committee on Library respectfully submits its annual report as follows:

The accretions to the library during the year 1905 comprised 2,132 titles, as against 2,397 in the preceding year.

The new acquisitions include:—

1,059 bound volumes,
292 unbound volumes,
768 pamphlets,
10 charts,
3 photographs.

These additions were derived from the following sources:

83 from the Bloomfield Moore Fund,
44 " " M. Carey Lea "
31 " " Jas. T. Morris "
9 " " Memorial Library "

81 through the *Journal* of the Institute,
12 " " exchange of duplicates,
272 by binding of periodicals,
1800 through bureaus of Federal and State governments, from various scientific institutions and societies at home and abroad, and through gifts from individual donors. Especially notable have been the contributions received from Messrs. George Westinghouse, Louis Teal, Caleb Milne, Carl Hering, Richard L. Humphrey, Arthur Falkenau, Cyrus Chambers, Edward D. Adams, Dr. Henry Leffmann, Dr. Solomon Solis-Cohen and Prof. Lewis M. Haupt. Some 45 volumes relating to the Paris Exposition of 1900 have been conditionally deposited in the library by Mr. Carl Hering.

The diminution of the number of volumes obtained by purchase—167 this year against 263 in 1904—while in some measures resulting from the fact that no part of the general library appropriation has this year been available for other than current necessities, is partly accounted for by the Committee's recent policy of utilizing the several special library funds for the purchase of larger and more important publications, such as are generally not within the compass of private libraries and which, on the other hand, are naturally to be sought in the collections of a scientific institute. Even this limitation has had to be further limited for lack of means adequate to the occasion, but, as far as possible, purchases have been made with the view of meeting the most general requirements of the library.

A number of imperfect volumes of general literary magazines, 218 in all, and a lot of duplicates, have been disposed of to make room for more strictly scientific publications. Duplicate public documents were returned to the various Government bureaus for re-distribution and some material was sold. The net result of the year in the library brings its contents to

59,089 volumes,
43,347 pamphlets,
690 drawings,
1,247 photos,
192 newspaper clippings,
31 manuscripts.

A total of..107,470 titles.

The library is greatly indebted to the efforts of Mr. Walter Wood, for a fund of $942.45, which was an unexpected balance of the money collected for the entertainment of the members of the Iron and Steel Institute at the recent meeting of that body in this city, and which, through Mr. Wood's initiative, was turned over to the Franklin Institute for the uses of its library. This fund has enabled the committee to make some much-needed improvements in the book stack and in the lower book rooms, and also to undertake the binding of a large number of volumes of periodicals which have hitherto had to be stored in parts, as well as to forward the arrangement and classification of the library's valuable collection of pamphlets.

A total of 336 volumes were bound up during the past year, including 309 volumes of serial publications, in addition to this some necessary rebindings and repairs were effected.

The library is in receipt of 558 different serial publications, an increase of 12 over the preceding year. As heretofore, nearly all of these are obtained through exchange for the *Journal* of the Franklin Institute, and they comprise issues in various languages from all quarters of the globe.

The library has been kept open until 10 o'clock on Thursday evenings, when the Section meetings occur, and on the occasion of the monthly meeting of the Institute on the third Wednesday evening. The number of visitors after night-fall tends rather to diminish than otherwise, and appears to be limited almost entirely to members attending the meetings. The daily attendance, on the other hand, is on the increase, indicating the growing importance of the library as a factor in the city's intellectual life.

LOUIS E. LEVY,
Chairman.

PHILADA., January 1, 1906.

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS FOR THE YEAR 1905.

To the President and Members of the Franklin Institute:

The Committee on Science and the Arts has the honor to submit the following account of its operations during the year 1905:

The total number of cases pending at the close of the year 1904 was 43, and the new cases proposed in 1905 numbered 26.

The total number of cases disposed of during 1905 was 28, leaving 41 cases pending at the present time.

There were granted, 1 "Elliott-Cresson Medal;" 14 "John Scott Medals;" 6 "Edward Longstreth Medals;" (21 medals in all). Two "Certificates of Merit" were awarded, and in five cases advisory reports were made.

The detailed statistics of the Committee will be found hereto appended.

The Chairman of the Committee has much pleasure in reporting that the efficiency of the Committee has been well maintained.

Respectfully sumbitted,

E. GOLDSMITH,
Chairman for 1905.

PHILADELPHIA, PA., January 3, 1906.

APPENDIX.

DETAILS OF THE COMMITTEE'S WORK IN 1905.

Number of cases pending on December 31, 1904	43	
Number of cases proposed in 1905	26	
Total number of cases before the Committee in 1905	—	69
Total number of cases finally disposed of in 1905	28	
Total number of cases pending on December 31, 1905	41	
	—	69

The 28 cases disposed of were determined as follows:

Award of the Elliott Cresson Medal	1
Award of the John Scott Legacy Premium and Medal	14

Award of the Edward Longstreth Medal of Merit..... 6
Award of the Certificate of Merit..... 2
Reports made advisory..... 5

Total 28

DETAILS OF AWARDS, ETC.

AWARDS OF THE ELLIOTT CRESSON MEDAL.

2281. Prof. M. I. Pupin, for his "Art of reducing the Attenuation of Electrical Waves and Apparatus."

AWARDS OF THE JOHN SCOTT LEGACY PREMIUM AND MEDAL.

2216. The Nernst Lamp Co., for their "Nernst Lamp."
2310. Dr. Persifor Frazer, for his "System of Quantitative Colorimetry."
2312. David J. Kurtz, for the "Cleveland Cap Screws and Bolts."
2313. John Bonner Semple, for his "Shell Torch or Tracer."
2322. Henry T. Hallowell, for his "Stardand Pressed Steel Products."
2329. Edward Parkinson, for his "Knitting Machine."
2338. Dr. A. Wehnelt, for his "Interrupter for Induction Coils."
2339. Dr. B. Walter, for his "Schaltung."
2342. Walter A. Rosenbaum, for his "Letter-Copying Press."
2357. Prof. Lino F. Rondinella, for his "Photo-Printing Machine."
2358. John M. Browning, for his "Automatic Pistols."
2360. Frederick E. Ives, for his "Replicas of Rowland Diffraction Gratings."
2368. Byron E. Eldred, for his "Process of Flame Regulation."

AWARDS OF THE EDWARD LONGSTRETH MEDAL.

2340. Miley & Son, for their "Color Photographs."
2348. Standard Elevator Interlock Co., for their "'Elevator Safety Devices."
2352. Phonosphere Mfg. Co., for their "Phonosphere."
2358. Colt Patent Firearms Mfg. Co., for their "Colt Automatic Pistols."
2364. Folmer & Schwing Mfg. Co., for their "Graflex Camera."
2367. Theodore Alteneder & Sons, for their "Drawing Pen."
2372. Henry Emerson Wetherill, for his "Physical Diagnostic Instruments."

AWARDS OF THE CERTIFICATE OF MERIT.

2331. International Burglar Immunity Co., for their "Electric Protective Devices."
2335. Samuel Eastman & Co., for their "Improved Fire Nozzle System."

REPORTS MADE ADVISORY.

2354. Emanuel Metzger, for his "Railway Car Cuspidor."
2355. Richard Raby, for his "Metallic Railway Tie."
2359. Mitford C. Massie, for his "Alternating Current Motor."
2377. William L. Barker, for his "System of Car Braking."

DISMISSED OR WITHDRAWN.

2344. "The Warren Rotary Engine."
2346. "Morris's Portable Roof."

REPORT OF THE COMMITTEE ON MEETINGS FOR THE YEAR 1905.

To the President and Members of the Franklin Institute:

The Committee on Meetings has arranged the programs of the usual number of meetings, with the assistance of the Secretary of the Institute. The Committee has nothing of special interest to report, and can only reiterate the statement contained in its report for the previous year, namely, that the growing activities of the Sections render it increasingly more difficult to retain for the monthly meetings the conspicuous place they occupied for many years.

The policy of preserving for presentation and discussion at the monthly meetings, subjects of general popular interest will be continued.

Respectfully submitted,

WASHINGTON JONES.
Chairman Committee on Meetings.

PHILADELPHIA, PA., January 3, 1906.

REPORT OF THE COMMITTEE ON PUBLICATIONS FOR THE YEAR 1905.

To the Board of Managers:

GENTLEMEN:—The Committee on Publications respectfully reports that the quantity of material offered for publication has been ample for its requirements. The Committee feels that the managers and members have cause for congratulation in the fact that the contributions to its pages through the Sections, meetings of the Institute and the several committees have made the *Journal* in recent years, what its name implies, the *Journal* of the Franklin Institute, indicating as it does, the continued scientific activity of the Institute. By reason of its contract entered into early in the year, the Committee is pleased to be able to say that the cost of publication has been greatly reduced and that it hopes to continue this economy for the future.

H. W. JAYNE,
Chairman Committee on Publication.

PHILADELPHIA, PA., January 4, 1906.

REPORT OF THE COMMITTEE ON INSTRUCTION FOR THE YEAR 1905.

To the Board of Managers:

The Committee on Instruction has been much gratified by the interest shown by members in the annual courses of popular scientific lectures,

which have been given in coöperation with the Central Branch of the Young Men's Christian Association. The experience of the past year was quite satisfactory. The subjects presented were all attractive and the participation of members large. The lecturers, with an occasional exception, have given their services gratuitously to the Institute, and due acknowledgement therefor has been made.

The Schools of Drawing, Machine Design and Naval Architecture have been fairly well patronized, as the accompanying comparative figures will exhibit:

	1904.	1905.
Drawing School	349	260
" " (Branch School)	201	217
School of Machine Design	87	96
School of Naval Architecture	38	28
Total	675	601

The Committee takes pleasure in acknowledging the effective coöperation of the recently-appointed professors and lecturers which has been of substantial value.

Respectfully submitted, WM. H. WAHL,
Chairman of Committee on Instruction.

PHILADELPHIA, PA., January 3, 1906.

ANNUAL REPORT OF THE COMMITTEE ON ELECTIONS AND RESIGNATIONS OF MEMBERS FOR THE YEAR 1905.

To the Board of Managers:

GENTLEMEN:—The Committee on Elections and Resignations of Members respectfully submits the following membership figures for the year 1905:

The systematic efforts to obtain new members has been continued, and the Committee's work, supplemented by that of a number of members, and the considerable assistance rendered by Mr. R. C. H. Brock, member of the Board, has resulted in placing on the rolls the names of 85 new members. The losses by death, resignation and non-payment of dues are noted in the accompanying schedule, showing a small loss numerically. The Committee again urges the members in general to participate in the work of increasing the numerical strength by inducing new persons to join. It is certainly possible for each member to obtain one new member in a year. The result of such action is easy to estimate.

The membership at the close of the year 1904 was	1597
New members secured in 1905	85
	1682
Loss by death, resignation and non-payment of dues	128
Members at the close of 1905	1554

Respectfully,

ALEX. KRUMBHAAR,
Chairman.

PHILA., January 1, 1906.

REPORT OF THE COMMITTEE ON SECTIONAL ARRANGEMENTS FOR THE YEAR 1905.

To the Board of Managers:

During the past year there were held no less than 32 meetings of the Sections, all of which were given up to the presentation of papers on subjects of scientific and technical interest, or to the discussion of live topics of general utility.

Much of the material printed in the *Journal* is derived from this source, and the uniform excellence of these articles affords the best testimony that could be desired to the value of the work of the Sections.

In accordance with resolutions passed by both Sections, the Chemical Section and the Physical Section have been united into a single Section, under the title of the Section of Physics and Chemistry. This union has received the Board's sanction.

The report of the Secretaries follows.

JAMES CHRISTIE,
Chairman Com. on Sectional Arrangements.

PHILADELPHIA, PA., January 3, 1906.

APPENDIX.

REPORT OF THE SECTIONS FOR THE YEAR 1905.

To the Committee on Sectional Arrangements:

The Sections of the Institute have just completed a year of gratifying activity. There were held 32 joint meetings, which were generally well attended, while the subjects presented and discussed were, as a rule, highly interesting and instructive. The *Journal* has benefitted greatly by the abundant supply of valuable material derived from this source.

The Sections in the past year, returned to their original plan of conducting their respective business affairs directly, instead of through an Executive Committee. It is thought that this will have the effect of keeping alive the idea of separate organizations, which was being gradually lost under the Executive Committee plan.

WM. H. WAHL,
For the Secretaries.

PHILADELPHIA, PA., January 3, 1906.